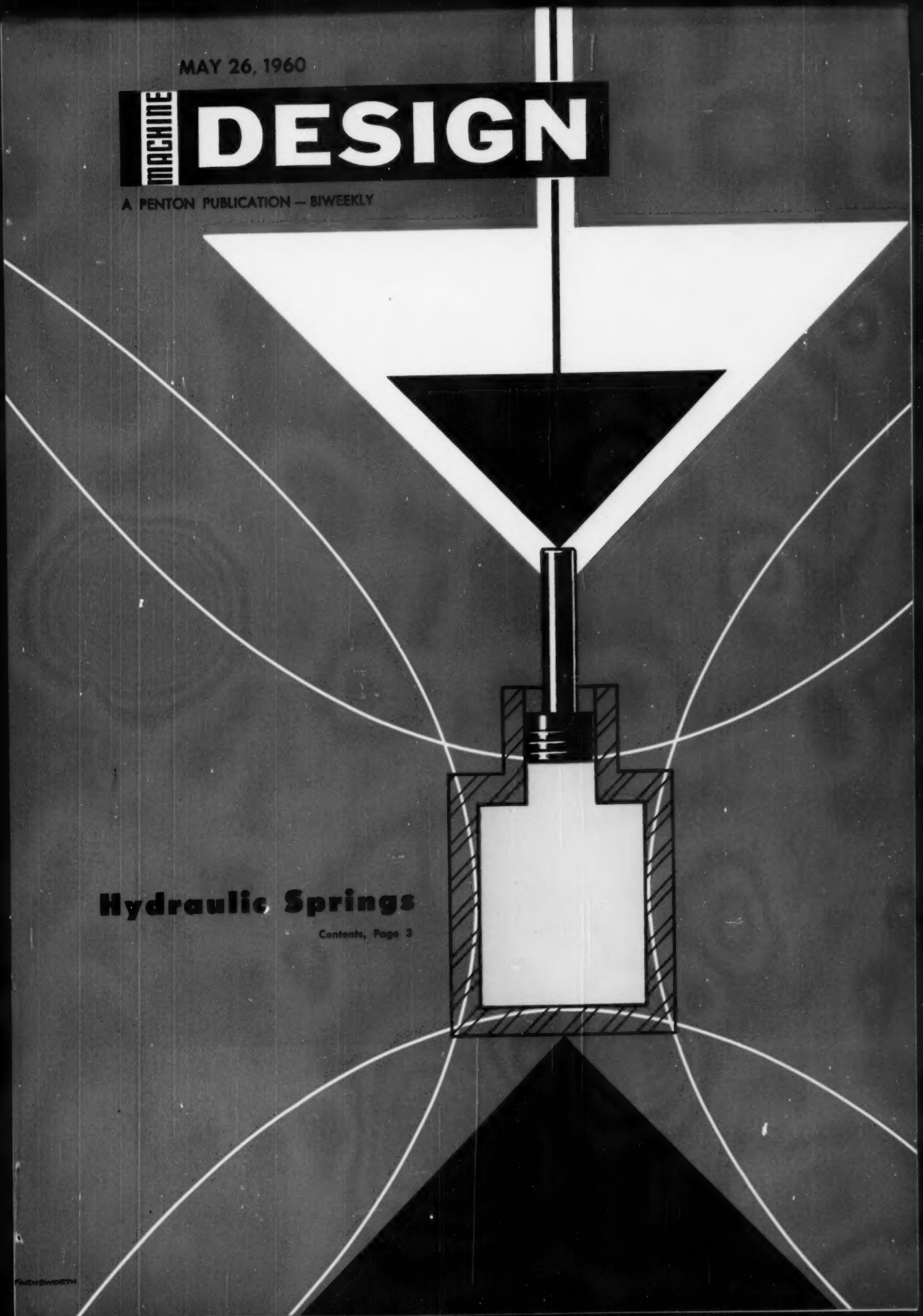
MAY 26, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Hydraulic Springs

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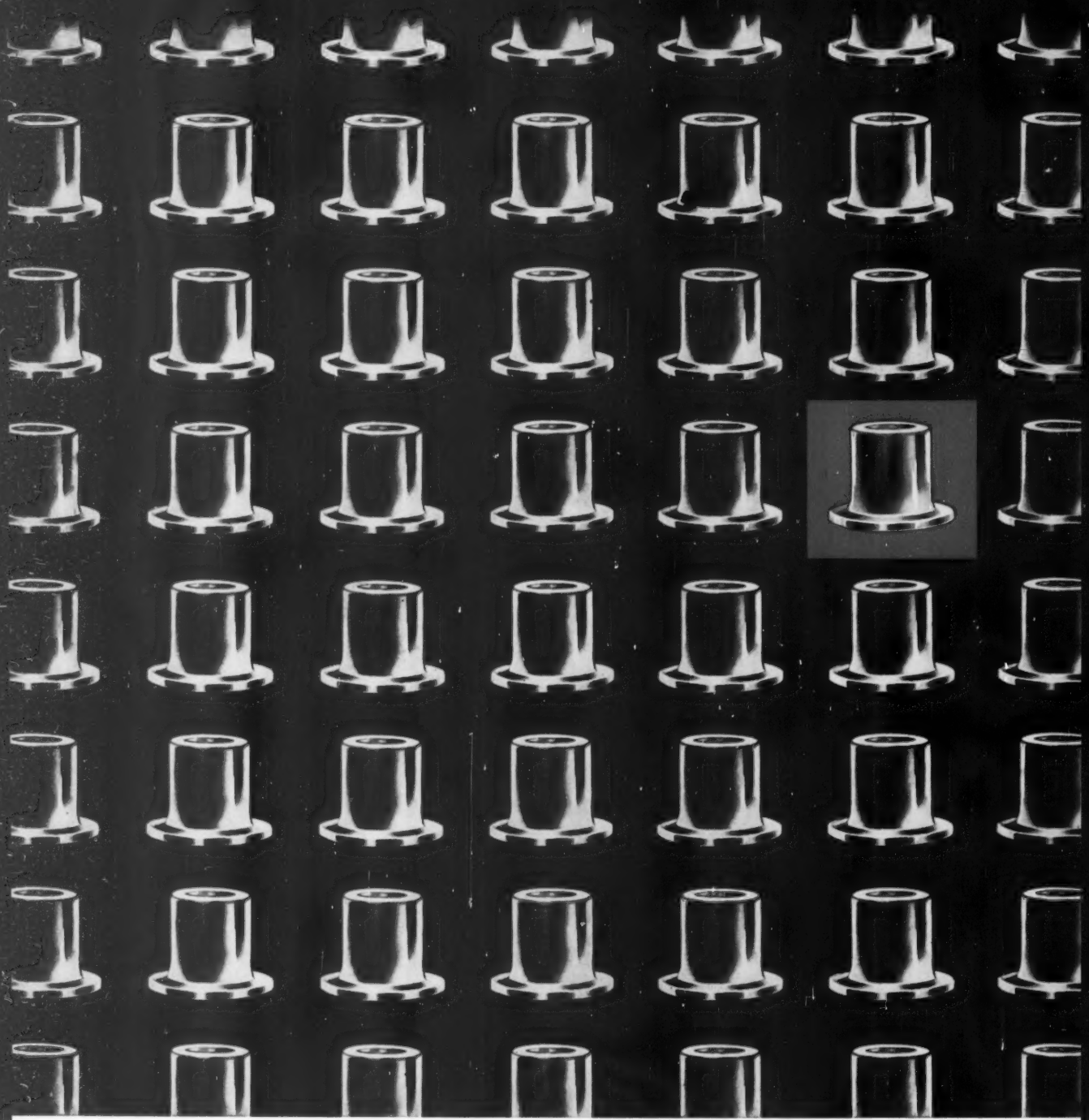

Which bearing for you? Which of 25 grades of sintered bronze or iron? How much oil content? What special properties? We can select and promptly deliver the one type of bearing that's *exactly* right for your application.

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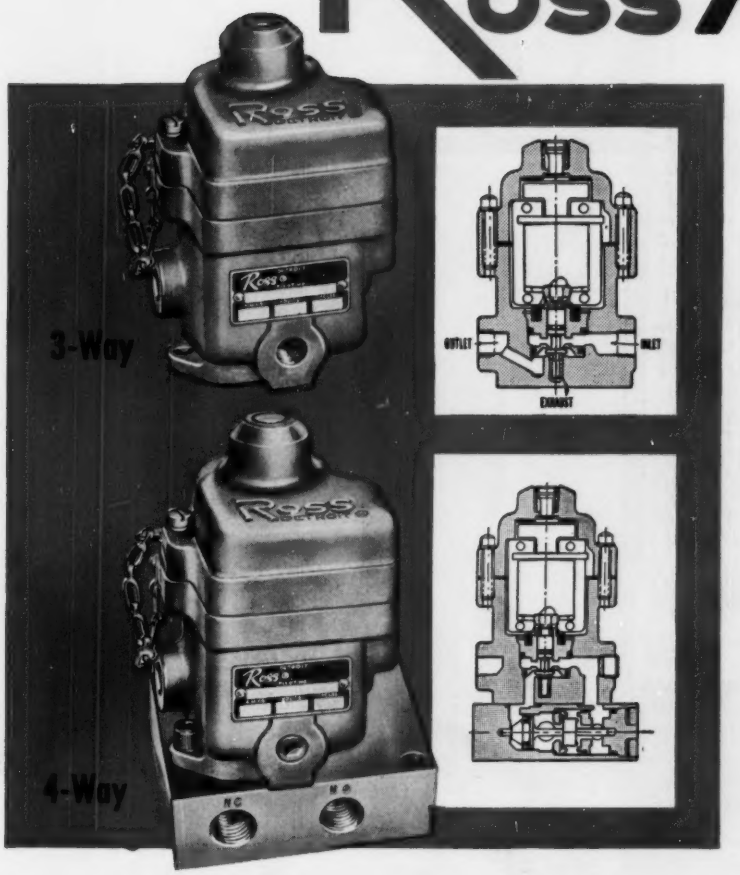
BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N. J. and Sturgis, Mich.

Announcing

a new and better solenoid valve in the $\frac{1}{8}$" and $\frac{1}{4}$" size range

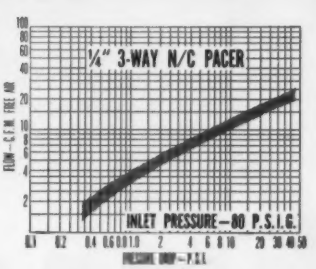
Ross PACER



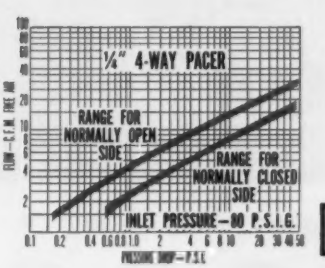
More life
More speed
More capacity
More value

Now you can have about three times more flow capacity-to-solenoid size than in most competitive valves. Needs just 7 watts of power yet minimum internal orifice size is full $\frac{5}{32}$". The PACER has short poppet travel, will cycle at better than 1000 cpm and meets JIC specifications. Lightweight, cast aluminum body means 3-way weighs just 20 ounces, 4-way just 28. Dust tight, liquid tight, can be manually actuated, has captive cover, is inoperative with cover removed, has integral wiring space. Why not test a PACER in your own circuit, just $18 for a 3-way, $26 for a PACER 4-way. Call your Ross representative or write for Bulletin 319.

Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



STAY AHEAD
MODERNIZE

Ross OPERATING VALVE COMPANY
109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

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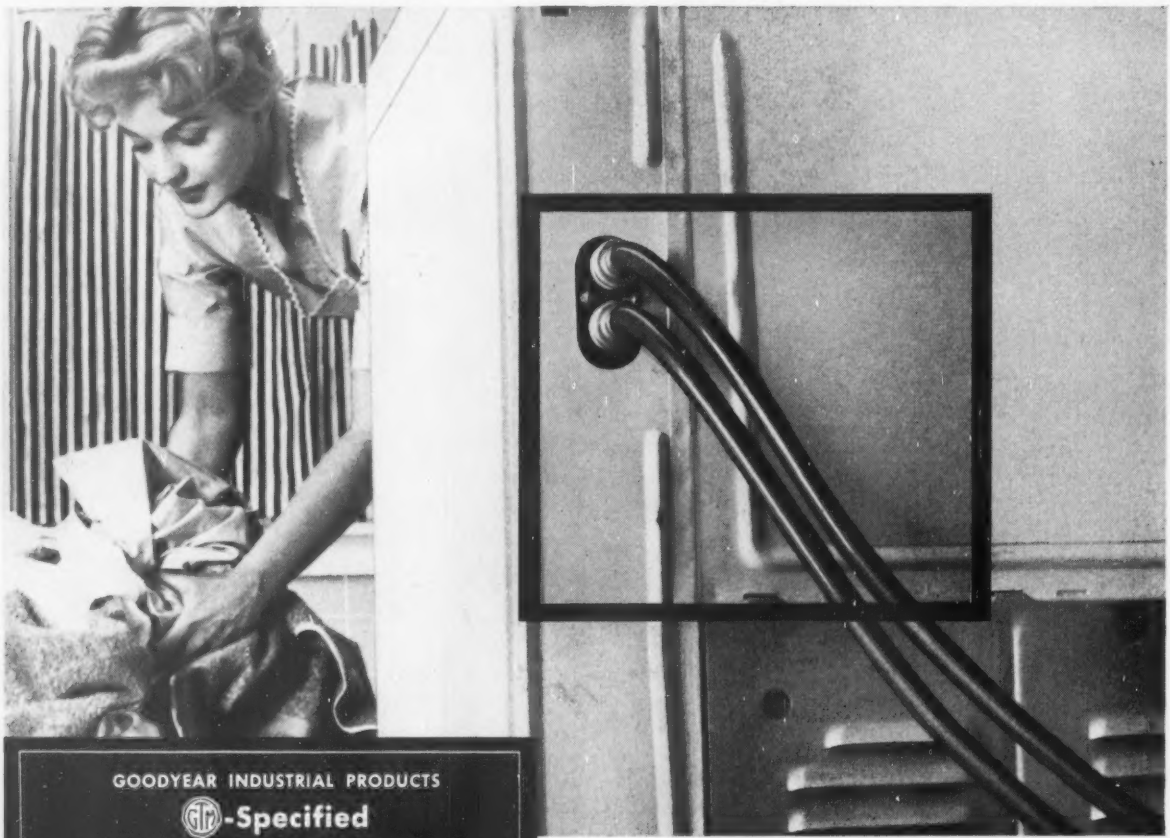
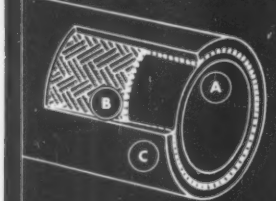
A new hose that won't pull itself out of couplings – won't jump during pressure changes – remains "relaxed" – answers a long-time problem of many washing-machine manufacturers. Called Acala, it was designed by the G.T.M. – Goodyear Technical Man – and his colleagues to minimize hose shrinkage under pressure – and the up-to-170-pound pull-off force that shrinkage produces. The secret: a unique Goodyear construction – first major advance in hose building since 1904. This built-in dimensional stability assures a relaxed hose during all washing operations – brings new reliability and safety not only to washing-machine applications but also to power steering or air-brake units and the like. Best of all, this far-advanced hose costs no more than conventional vertically braided types.



GOODYEAR INDUSTRIAL PRODUCTS

GTM-Specified

Acala Hose that won't shrink under internal pressure



A Nonporous, non-clogging, heat-resisting rubber tube

B Special optimum-angle braided construction minimizes shrinkage under internal pressure

C Non-marking, heat-resistant cover

The G.T.M. – and the tremendous Goodyear research facilities – are always at work on real advances in industrial rubber like this.

That's why they've made so many important contributions to every rubber-using industry. It's the big reason, too, why you can always count on Goodyear for problem-solvers like the new Acala Hose. For full details, write Goodyear, Industrial Products Division, Akron 16, Ohio.

Lots of good things come from

GOODYEAR

Acala–T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

THE GREATEST NAME IN RUBBER

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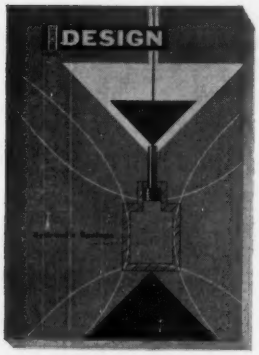

Front Cover: Big force, small spring, small deflection—these are the contrasting elements used by artist George Farnsworth to portray the unique operating characteristics of the hydraulic spring. A more detailed analysis of the characteristics of these springs is given in the article by Leonard Johnson on Page 114.

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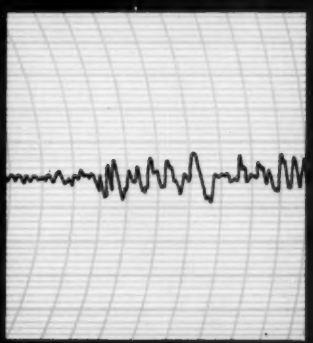
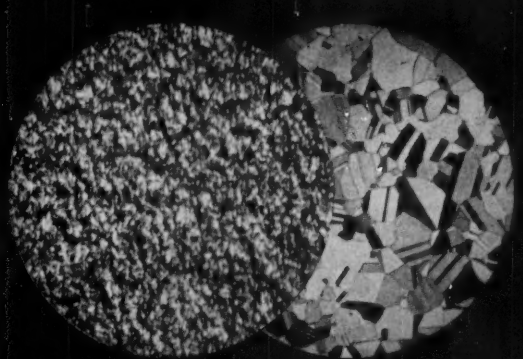
THESE SURFACE TRACES

prove that you can cut polishing costs with Formbrite, Anaconda's superfine-grain drawing brass.

STANDARD DRAWING BRASS
(grain size, .045 mm) – after 40% elongation

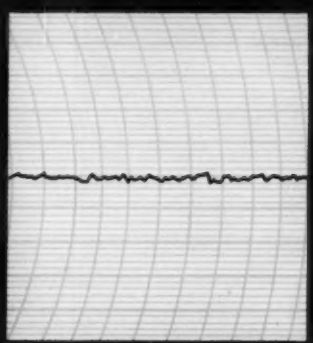


ENLARGED SURFACE TRACE showing the roughness that causes "orange-peel" effect in the working of standard drawing brass. Smoothing such mountains down to the valleys takes considerable cutting. For small deep-drawn products, up to five polishing wheels might be needed. Polishing compound costs run high; production rates, low. Bottlenecks hamstring operations.

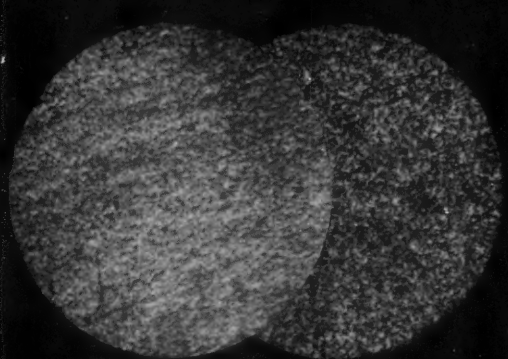


THE STRETCHED SAMPLE of standard drawing brass looks like this (left, above) when seen in oblique illumination and magnified 20x. Its microstructure is shown 75x at right. This is the kind of drawing brass that's been used for decades for stamped or drawn brass products and the micrographs show in another way why polishing costs have been high.

FORMBRITE DRAWING BRASS
(grain size, .005 mm) – after 40% elongation



ENLARGED SURFACE TRACE showing Formbrite's smoothness even after deformation, the test of polishing characteristics of a drawing brass. It is relatively easy to level these little hills on the surface of Formbrite. In many cases, users find they eliminate cutting operations altogether, need only a simple color buff. Finishing savings run up to 50%.



WHEN SEEN IN OBLIQUE ILLUMINATION and magnified 20x by the microscope, the stretched Formbrite surface looks like this (at left, above). Its microstructure is shown 75x at the right. This uniform superfine-grain structure is produced by special procedures of rolling and annealing developed by The American Brass Company.

FORMBRITE is springier, harder, more scratch resistant than the usual drawing brasses in the same standard tempers. Yet it retains remarkable ductility for forming and drawing—even such deep-drawn products as pen barrels. And Formbrite costs no more than ordinary drawing brass, despite its superiority. Get full details from your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

6048

FORMBRITE®

Superfine-Grain Drawing Brass an

ANACONDA®

product made by The American Brass Company

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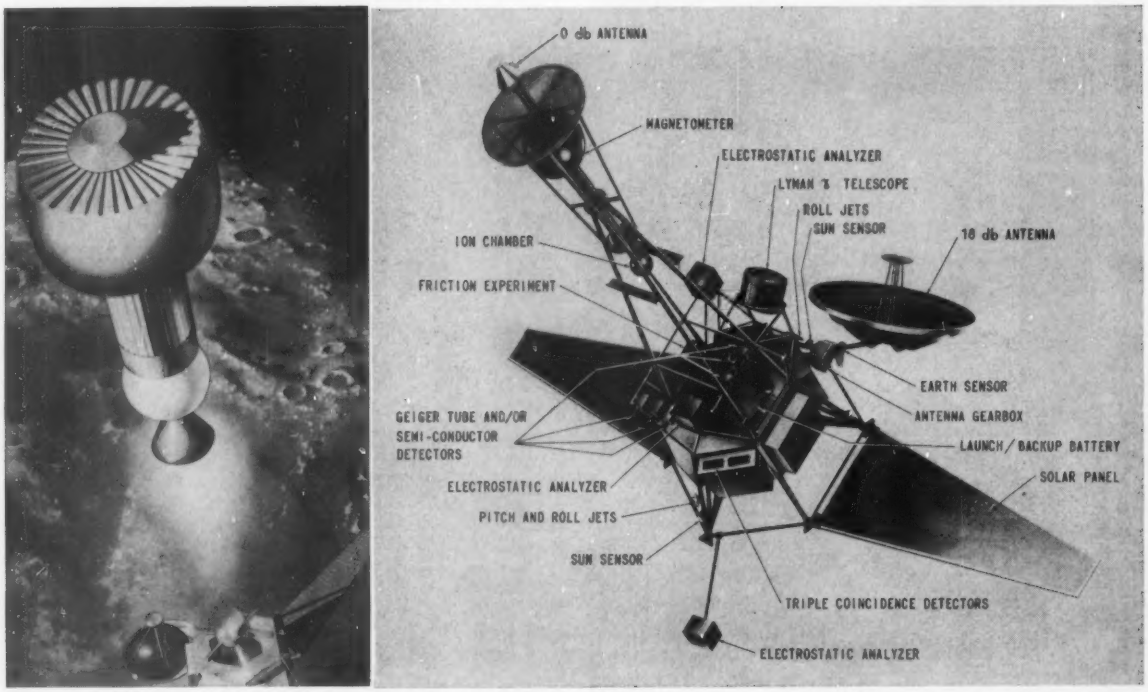
ENGINEERING NEWS



Ranger will be ready next year to carry an instrument payload to the moon. Scientific package on the front of the vehicle (right) will be removed for mounting of the impact capsule (left), and mid-course propulsion system will be added to permit maneuverability. At distance of 20-25 miles from the moon, the mushroom-shaped capsule will separate, and a retro rocket will slow its speed to about 200 mph at impact. Crushable honeycomb structure will absorb the shock. Capsule's transmitter is expected to broadcast from the moon for at least one month.

NASA Readies Probes to Moon, Mars, Venus

Soft Lunar Landing Is Scheduled First

LOS ANGELES—Fast-breaking events in the U. S. space program include the final design this year, and launching next year, of a lunar-impact vehicle. NASA's Jet Propulsion Laboratory has disclosed details of the lunar device, and has outlined a launching schedule that will carry similar probes to Mars and Venus sometime in 1962.

Clifford I. Cummings, JPL's spacecraft program director, says the lunar vehicle, called Ranger, will be about 12 ft long and weigh 700 to 800 lb. It will be launched by an Atlas-Agena-B combination. For trips to Mars and Venus, the Atlas-Centaur configuration will be the launching vehicle.

Early this month, JPL gave Ford Motor Co.'s Aeronutronic Div. the job of developing the survival (impact) capsule which will ride on the lunar bus. The capsule will contain an impact accelerometer, thermometer to measure moon surface temperature, and a seismometer to measure moon quakes and meteor impacts. It will also contain the necessary power supply, transmitter and broadcasting antenna.

Impacts are not planned for the Mars and Venus excursions in '62. Ranger will pass within a "few thousand miles" of the planets and probe their atmospheres with radar, infrared scanners, and other sensing equipment. During the Mars flyby, a detailed infrared picture mosaic is scheduled to be taken. The picture will be divided into a number of reasonably small squares, and the infrared response within each square will be indicated. This should result in definite knowledge concerning plant life on the red planet. Visual photographs will also be taken of Mars adding to the knowledge about the planet's visual spectrum.

Attempts will also be made to gain detailed knowledge about the surface of Venus, although penetration of the atmosphere may prove unsuccessful. A fairly detailed analysis of the atmosphere would be a significant achievement, however.

... Fluid Power NEWS

REPORT NO. 12,107
HYTAC* **AIDS MAKING OF NEW EXTENSIBLE PAPER**

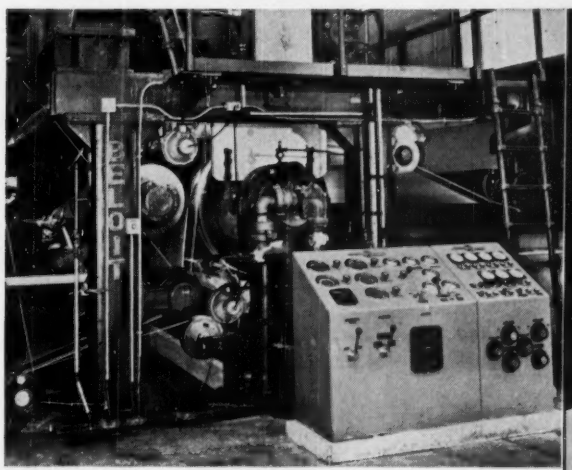
From Oilgear *Application-Engineering* Files

HOW *HYTAC** SYSTEMS CONTROL NEW EXTENSIBLE PAPER MACHINE SECTION SPEEDS IN 12 MILLS

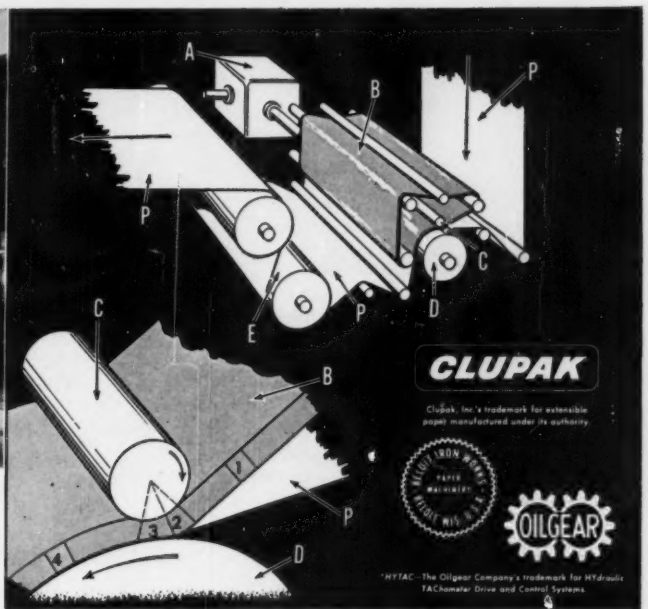
USERS: *Twelve Paper Companies — Licensed by CLUPAK, INC.*

Builder — Sections and Differential Drives — Beloit Iron Works, Beloit, Wisconsin

DATA: Systems to vary and precisely control speed and draw of new sections that can be an integral part of complete, new paper machines, or inserted into existing machines for production of CLUPAK® extensible paper—a revolutionary, patented, smooth, tough, kraft sheet. Original requirements called for systems that, when applied to *Beloit* mechanical differentials, would: *1.* Provide precision-controlled, infinitely variable section speed decrease up to 10% under main lineshaft speed—as selected from remote pushbutton stations. *2.* Maintain selected section speed within ±0.25% max. variation over a 50% load change at max. lineshaft speed. *3.* Be: compact; impervious to heat, high humidity; thrifty on electrical power input, wiring, installation downtime, floor space; completely free, if possible, from maintenance-provoking belts, chains, relays. *4.* Insure trouble-free, continuous, heavy-duty, full-production paper machine drive service—but permit section immobilization for production of non-extensible stock. *5.* One source and responsibility for these speed and draw controls preferred.



One of the most recent of the twelve new **Beloit** extensible sections and control consoles incorporating **HYTAC* SYSTEMS** for precise speed and draw control—as installed on No. 1 machine at **International Paper Company's Southern Kraft Division Mill, Camden, Arkansas,** to produce CLUPAK® extensible paper. Control console instrumentation includes direct-reading hydraulic pressure gages from the **OILGEAR System** to provide operators with constant, visual, exact indication of load or draw on the section.



HOW IT WORKS: Section driven by Oilgear-equipped **Beloit** differential (A), consists of a 1-in. thick natural rubber Blanket (B) operating over 3 rolls, and between Nip Roll (C) and steam-heated, polished, chrome plated Dryer Drum (D). Paper (P) is held between Blanket (B), slipping against Dryer Drum (D). Enlarged view at Nip Roll shows how normal (1) Blanket (B) is compressed (2), squeezed and elongated (3), and rapidly contracts (4) after leaving Nip Roll—shrinking paper. Normal production shrink requirement is accurately controllable up to 15% by controlled variation in nip pressure, moisture content, dryer drum temperature. Accurate control of draw in and between extensible unit and 3rd Dryer Section (E) is required regardless of load changes . . . a reason for the precise, infinitely variable speed-draw control provided by Application-Engineered **HYTAC® Systems.**

SOLUTION: Application-Engineered *HYTAC** (HY*draulic* TA*Chometer*) controlled differential drives consisting of Oilgear "DRt-3517" Variable Displacement Pumps, "H-6017" Constant Displacement Motors, and *HYTAC** components with remote pushbutton control to provide precise speed-draw control on *Beloit* extensible sections installed and commercially producing CLUPAK® extensible paper at nine mills in the United States, two in Canada, and one in Sweden. Several other paper manufacturers licensed by CLUPAK, Inc., to produce extensible paper under its authority, now have these Oilgear-equipped *Beloit* extensible sections on order. Oilgear *HYTAC** Drive-Control Systems were selected after 3 years of development on this process and machine—from a 2-in. table model, through a 15-in. laboratory model, and a 60-in. pilot model—as best suited to provide the accuracy and range of control required for the variable speed drives. *Actual commercial operation has proved that these highly accurate, compact, heavy-duty, Oilgear Systems can maintain any selected section speed with less than ±0.25% variation* regardless of load change *over a 10:1 range of lineshaft rpm—plus enabling operators to infinitely vary each section's drive rpm up to 15% under main lineshaft rpm . . . exceeding originally specified requirements!*

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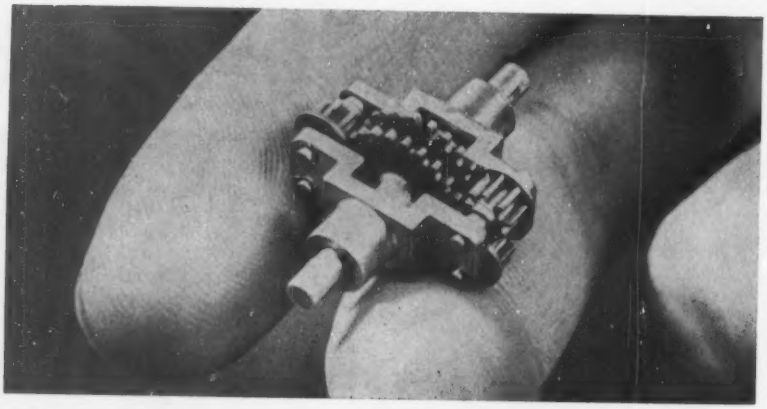
Other inherent Oilgear "Any-Speed" Drive features are: cushioned, controlled starting, acceleration, deceleration, braking . . . positive, automatic overload protection . . . continuously filtered pressure and flood lubrication. Copies of Oilgear's *Fluid Power NEWS* 3, 5, 8, 9, 11—with detailed descriptions of some of these and other *Application-Proved* installations are available on request.

For practical solutions to your linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY
Application-Engineered Controlled Motion Systems
1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN
Phone: Mitchell 5-6715 . . . Direct Distance Dialing Code 414

Recorder of Hard Knocks

Shock-overload indicator mounted with sensitive equipment during transit indicates excessive shock that may have occurred. Stool pigeon is a red spot that appears behind a clear plastic window when a spring-loaded mass is tripped. The unit is sensitive to acceleration in one direction in the longitudinal axis and in all transverse directions. Two units mounted back-to-back provide full spherical sensitivity. Convair Div., General Dynamics Corp., developed the indicator.



Differential for a Dime

Very low-cost mechanical differentials—cast as one-piece units—have been developed. Using die-cast zinc gears and housings, they are expected to find uses in tuning devices, toys, vending machines, and similar applications where transmission problems involving light loads are encountered. Gries Reproducer Corp., New Rochelle, N. Y., claims its unique, fully automatic process will enable it to turn out complex differentials complete with intricate external details for less than ten cents each. Government surplus units sell for about $4.00 each.

Cold-Cast Ceramics

New York, N. Y.—Ceramic powders that can be cast at room temperature are being used to make high-temperature tools, jigs, and fixtures. The development promises to be a boon to the aircraft and missile industry, where many exotic materials are formed with great heat and pressure.

The ceramic powders are dimensionally stable in use and have high compressive strengths. Molded to the required forms when and where the user wants them, the hot-tooling shapes can be put to work immediately. Chemical and ceramic bonding occur during use.

Two powders have been developed by Corning Glass Works, under the names Corcast and Cortamp. Corcast is a hydraulically bonded petalite, with a density of about 110 lb per cu ft. Drying causes negligible shrinkage, and the as-cast piece is ready for work, unless grinding is required. Service temperature for the material is 2500 F; coefficient of thermal expansion, almost zero; compressive strength, 2000-3000 psi.

Cortamp, a multi-bonded zircon, is molded by compaction. The initial organic bond changes to a chemical bond at 1300 F, and again to a ceramic bond at 2700 F. Service temperature for Cortamp is 4000 F, and its compressive strength is from 10,000 to 12,000 psi. The material can be ground and machined.

Topics

Help on the highway could be summoned via radio signals with a system developed by Hoffman Electronics Corp., Los Angeles. Small FM transmitters would be located on light poles at ¼-mile intervals. Signals, which would indicate location and type of trouble, would be received at police stations. The transmitters are powered by nickel-cadmium batteries, recharged by solar energy.

• • •

Magnetism damps vibration in an airplane's skin. Field of a permanent magnet attached to the plane's frame envelops an aluminum ring which is fastened to the panel, or section of the skin. When the panel vibrates, the aluminum ring moves back and forth in the permanent magnet's field, causing flow of an electric current in the ring. This current reacts with the magnet to stop vibration.

• • •

Thinner tin cans will result from a new plating process developed by U. S. Steel Corp. The tin plate—reported to have added strength and rigidity—is about half the thickness and weight of anything now used in cans.

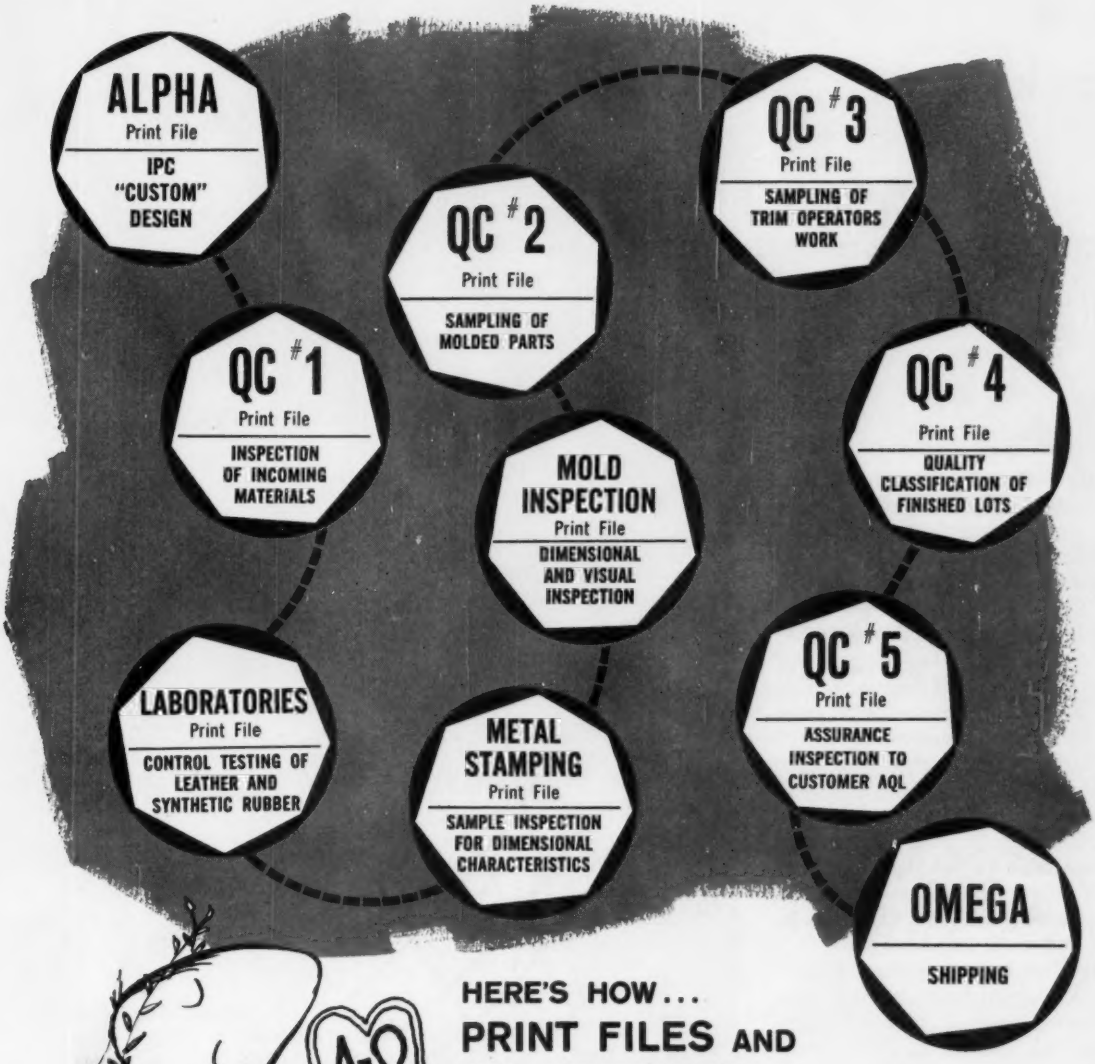
• • •

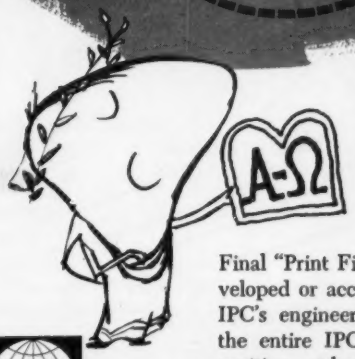
Redwoods aid radiation study by proving that the living cell can cope with small amounts of radiation. This conclusion was reached by Dr. Theodore N. Tahmisian, Argonne National Laboratory scientist, after studying California's sequoia trees to determine if natural radiation (from cosmic rays and radioactive materials in the soil) affected growth potential of the seeds or caused abnormalities in cell division. Examination of germinated seeds indicated normal cell division and normal chromosomes. The sequoias, which have been exposed to natural radiation for 2000 to 4000 years, receive about 115 roentgens per thousand years in the area where the seeds grow. A human being soaks up 10 or 15 roentgens in 60 years.

• • •

A sort of common thermometer takes everyone's temperature at once in the Edinburgh Royal Infirmary. This transistor and battery-operated device, described as a clinical electronic thermometer, consists of a meter, a switch, and highly sensitive thermistors. Electrical resistance of the thermistor changes with the application of heat, indicating temperature. Strapped to patients and connected by wires to the nurses' headquarters, these remote thermometers can keep tab on an unlimited number of patients.

From beginning to end... *and in between...* IPC controls quality in manufacturing OIL SEALS... PACKINGS... PRECISION MOLDING





HERE'S HOW... PRINT FILES AND QC STATIONS

Final "Print Files" for every product developed or accepted for manufacture by IPC's engineers are located throughout the entire IPC plant. These provide a positive, at-hand reference for product quality!

More than this . . . IPC maintains Q C (Quality Control) stations at strategic locations in the manufacturing line *through which every batch of manufactured parts MUST pass* before they are committed to shipment.

IPC's reputation for quality is no mere coincidence. It's the planned cornerstone of customer relations. We may err, as humans will, but we've reduced the incidence of error to an absolute minimum. Try us . . . or better yet arrange to visit our plant. We'll be happy to show you how IPC Quality Control benefits America's most critical manufacturers.

IPC

OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed for your application.

INTERNATIONAL PACKINGS CORPORATION

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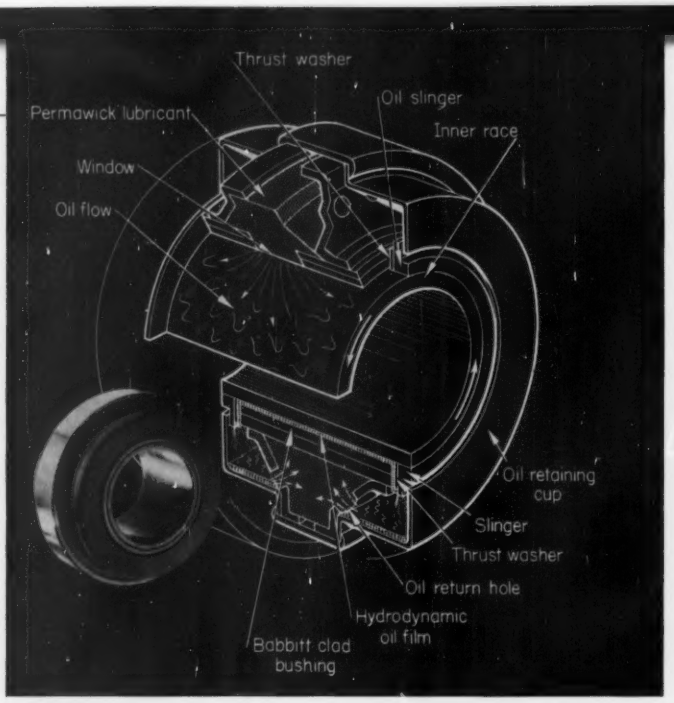
Bristol, New Hampshire P-3

Sleeve Bearing in a Package

. . . first off-the-shelf unit with hydrodynamic lubrication promises 20,000-hr base life

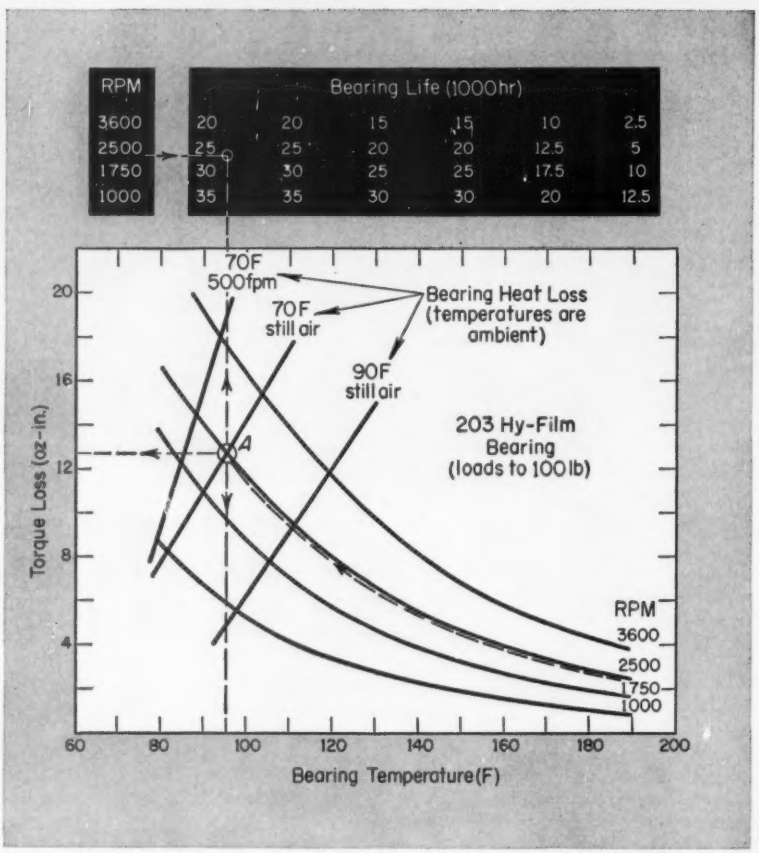


DETROIT—A hydrodynamic oil film—maintained by a sealed-in, recirculating lube supply—gives a new Hy-Film packaged sleeve bearing an estimated base life exceeding 20,000 hr. And because the weight-bearing film completely eliminates metal-to-metal contact (a design first for an off-the-shelf bearing), this life is probably conservative, says the developer, Tann Bearing Co.

Aiming at applications until now solidly in the ball-bearing bailiwick, Tann is scheduling volume production in bore sizes from 8 to 40 mm. All models—to be available from stock after September—are interchangeable with ball bearings in bore and shaft requirements.

Hy-Film is built around a windowed, babbitt-lined bushing and a lifetime reservoir of self-wicking Permawick lubricant. The inner "race" (steel) is comparable in function and tolerance to a ball-bearing race. Oil, released to the shaft through the window, sets up the hydrodynamic film, is then recirculated by slingers to the reservoir. In effect, the lubricant release and re-absorption cycle constitutes an internally regulated, self-metering oil system.

Operating virtually free of vibration, Hy-Film is designed for any service where quiet running is essential (appliances, fans, etc.), or in gritty or humid enviroments—as in grinders, pumps, and construction machinery. A unique auxiliary feature: Fibers in the Permawick lube filter out any impurities in the oil.



Typical test data (Model 203 bearing) were collected to verify life-load-speed-heat calculations. Bearing temperature on horizontal axis was measured by a thermocouple held in contact with the bearing's outer diameter. Heat-loss curves show influence of ambient-air temperature and velocity. Point A illustrates method for finding bearing life: 1. Assume 2500-rpm application in 70-F still air; follow dashed line upward to point A. 2. Read torque loss (about 12.75 oz-in.) on vertical axis. 3. Read bearing outside-diameter temperature (about 95 F) on horizontal axis. 4. Follow dashed line upward from A, read bearing base life (25,000 hr) for assumed speed and temperature.

CASE HISTORIES

Special high-temperature, full complement N/D ball bearing, made of cobalt base alloy, operates successfully at high temperature with no need for lubricant protection!

Photo: Courtesy Stratos Division, Fairchild Engine and Airplane Corp.

Special Alloy Ball Bearings Keep Butterfly Valve Modulating at 900° F.!

CUSTOMER PROBLEM:
Require highly heat-resistant ball bearings for butterfly valve which modulates 900° F. hot air blast in turbine air bleed. Despite radial loads up to 300 lbs., shaft must turn effortlessly through 65°.

SOLUTION:
New Departure Sales Engineers, cooperating with Stratos, manufacturer of the auxiliary power turbine, recommended N/D's special aircraft ball bearing of cast cobalt base alloy for this critical application. These bearings were selected for their ability to withstand extremely high temperatures without deterioration.

Extensive testing proved that this N/D equipped modulating system, currently used on the Lockheed Hercules C-130A, military transport, operates at required standards of performance and reliability . . . and without lubrication! In addition, other New Departure ball bearings, selected for their unsurpassed reliability, are used to support the turbine main shaft which operates at 45,000 rpm.

If you're looking for bearings that operate efficiently at unusually high temperatures and speeds, contact your local N/D Sales Engineer. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

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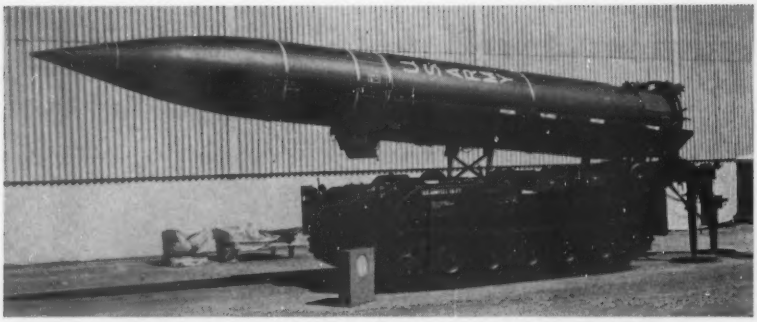
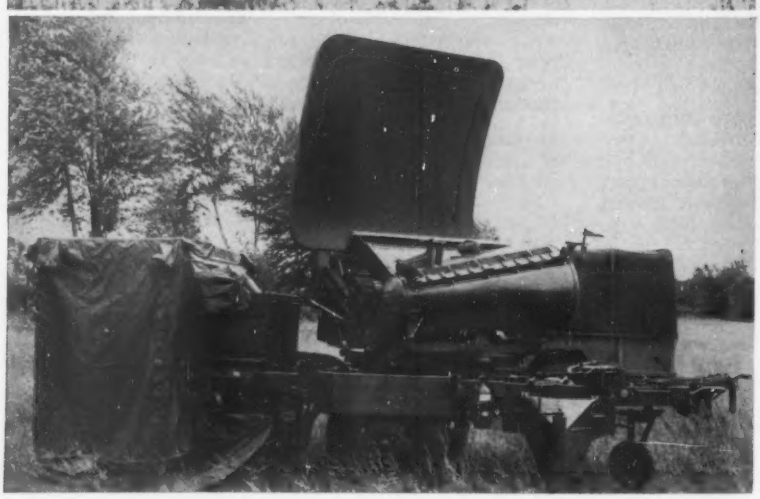


Army Develops Quick Reflexes

"Shoot and scoot" philosophy was emphasized by Army during the recent Project MAN (Modern Army Needs) demonstration at Ft. Benning, Ga. Impressive weapons on display included Pershing (top), the two-stage selective-range ballistic missile that will replace Redstone. Mounted on its own transporter-erector-launcher, which is carried, in turn, on the back of a tracked vehicle, the solid-fuel weapon can be erected and fired in a matter of minutes, is guided by an all-inertial system. Jeep-mounted Davy Crockett (center) is a formidable new infantry arm with nuclear capability. Recoilless and man-portable, the light-weight weapon is made almost entirely of titanium. Trailer mounted mortar-locator radar (below), developed for the Signal Corps by General Electric, detects mortar shells in flight, computes trajectory, and pinpoints location of enemy mortar batteries for prompt retaliation.

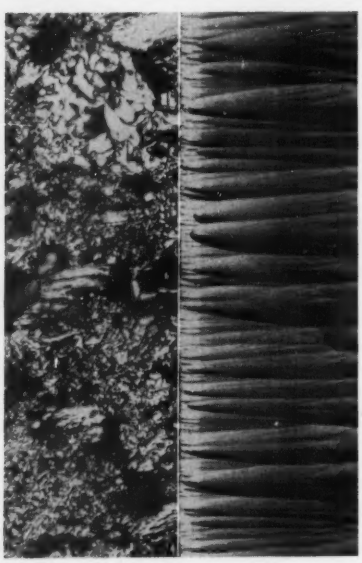


GE Breaks Bottleneck In Supergraphite Production

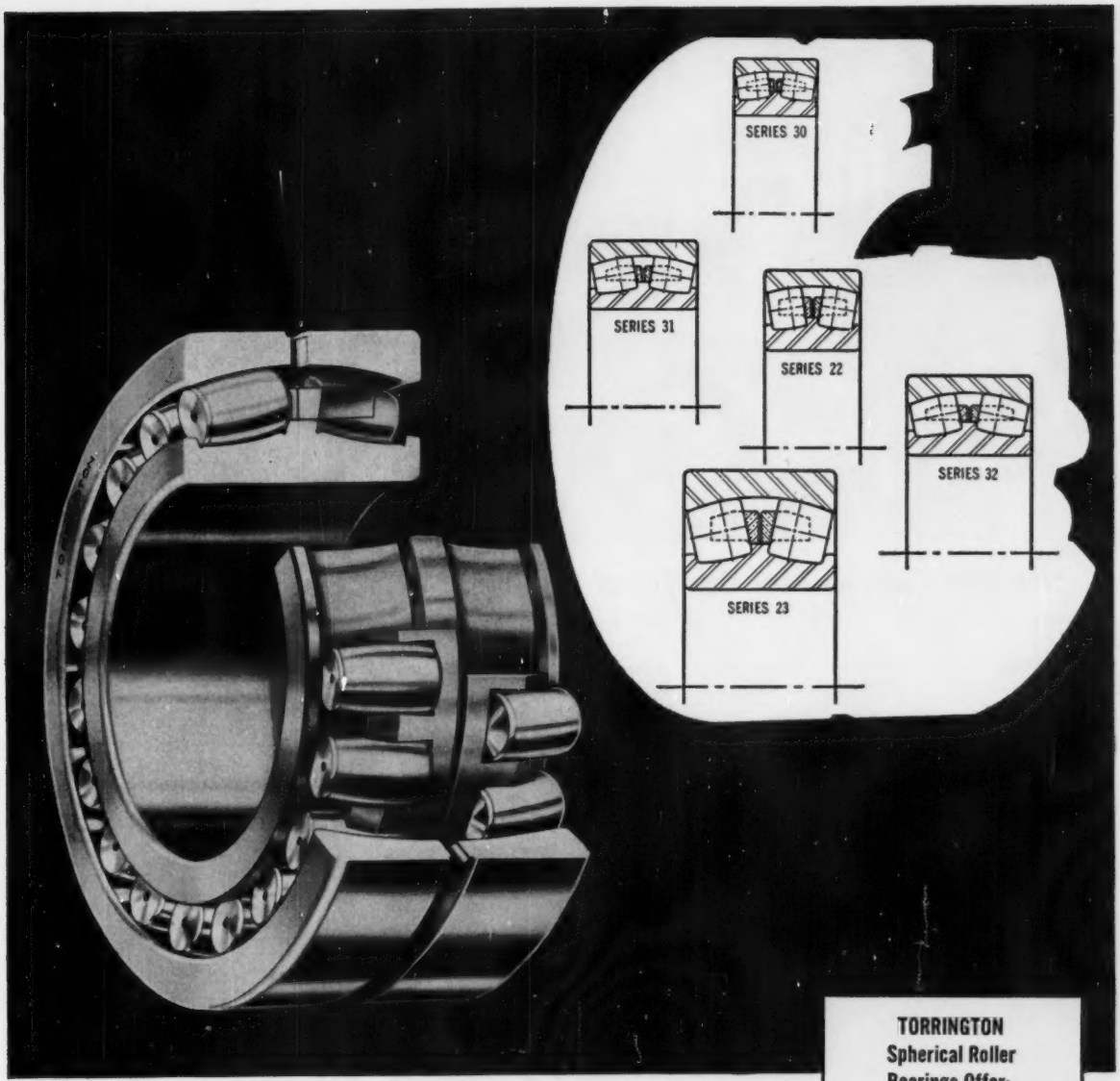
SCHENECTADY, N. Y.—Pyrolitic graphite, the original supermaterial (it's been around since 1883), may soon be available in useful-size pieces. General Electric researchers, trying out a new production process, have made the biggest sample so far—a slab, 17 x 31 x ⅛ in.

In the new technique, GE places a heated piece of commercial graphite in a hydrocarbon-gas stream (methane). As the graphite picks up carbon from the gas, crystals of oriented graphite form with their flat surfaces parallel to the existing surface, building up an almost homogeneous structure. Crystals join each other with strong bonds along the flat planes, but bonds between layers are weak.

Unusual properties of the oriented graphite result from its atomic structure (MD, December 10, 1959, p. 36). Heat travels hundreds of times more easily along the layers than through them. Other properties, e.g., strength and corrosion resistance, also vary sharply, depending on the direction in which they are measured.



Crystals of ordinary graphite (left) line up in a random arrangement. In pyrolitic graphite (right) crystals align in orderly stacks. Structural uniformity accounts for unusual properties of pyrolitic graphite: Above 3000 F it has the highest strength-to-weight ratio of any high-temperature material now being considered; above 5000 F its tensile strength approaches 40,000 psi.



There's a Torrington Spherical Roller Bearing for your application

Bearings matched *exactly* to the job pay off in better performance, longer life, greater reliability. That's why it pays to specify carefully. And that's why it pays to choose Torrington Spherical Roller Bearings.

Whatever your space limitations or capacity requirements, the five series of Torrington Spherical Roller Bearings provide the right bearing for virtually every industrial application. You can design for straight bore or tapered bore with adapter. You can benefit from extra features such as lubrication groove and oil holes, or selected outside diameters.

Your use of Torrington Spherical Roller Bearings will assure exceptional operation and longer bearing life under the toughest conditions. They're made to Torrington's own uncompromising standards—the highest in the field of anti-friction engineering—by the manufacturer of every basic type of anti-friction bearing.

TORRINGTON Spherical Roller Bearings Offer:

- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- inherent self-alignment
- even load distribution
- long, dependable service life

Send for new Torrington Spherical Roller Bearing Catalog #258

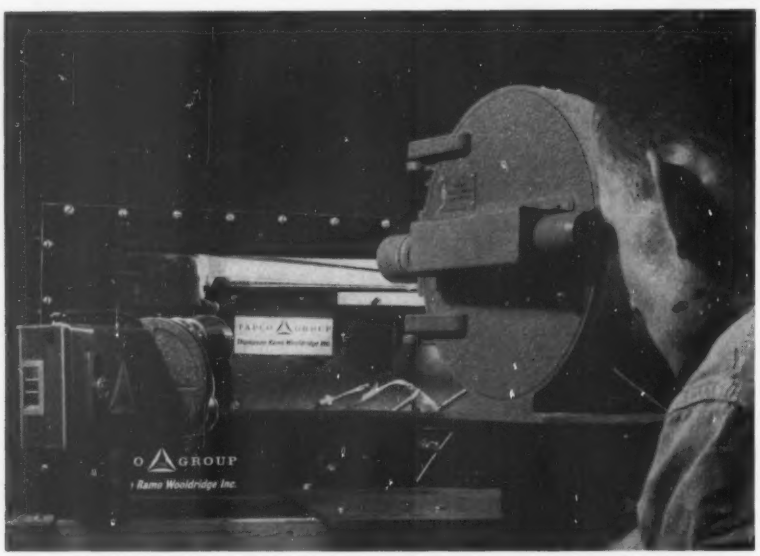
progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

Circle 410 on Page 19

'Copter Pilot Controls Rear Gun Turret

Accurate aiming of a surveillance camera or machine gun will be accomplished by a remote transistorized control system. In its first application, the system points a lightweight gun-turret mounted on the nose or tail of any helicopter. Pilot's control is a freely maneuverable cockpit-mounted pistol grip. General Electric claims the turret, weighing less than 80 lb, can handle loads up to 150 lb, rotate through 370 degrees, and permit a vertical movement through 90 degrees. Utilizing power from a standard 24-volt battery, the system is all-electric. The cockpit hand control can be easily stowed away when not in use.



Zero Gravity No Problem For Space Boiler

Pioneering experiments are underway to investigate boiling and condensing of fluids under zero gravity conditions. The test apparatus was "flown" in an orbital force field, while the working fluid (in a closed loop Rankine cycle) was evaporated and then condensed. It was found that the condensate could be collected normally, and preliminary conclusions are that a stable condenser-subcooler can be maintained. A simple technique has been supplied to prevent any substantial amount of fluid from being expelled from the boiler. Thompson Ramo Wooldridge Inc. is running the tests in co-operation with Atomic Energy Commission and Wright Air Development Division.

Impact Extrusions Put New Shapes in Aluminum

High temperature performance and retention of properties are claimed for aluminum parts made by a new extrusion process. The technique combines the advantages of extruding with those of impacting and powder metallurgy. One prototype part fabricated by the process—a ¼-in. diameter finned tube, impacted in lengths up to 14 ft—cannot be manufactured by any other method, according to Aluminum Co. of America. Tolerances for wall thickness are 0.003 in. In theory, any part that can be impacted can be made to the same close tolerances.

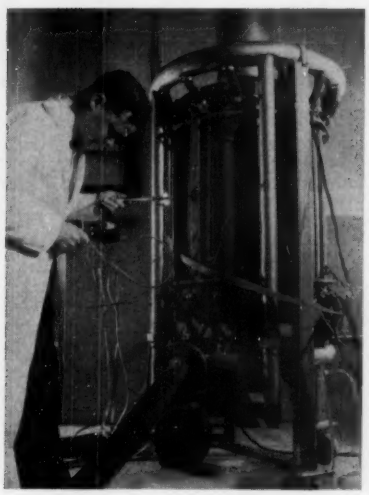
Molecule Counter Proposed To Solve Computer Problem

GOLETA, CALIF. — A method of counting individual molecules may upgrade the art of digital computing. Scientists at Servomechanisms Inc., Goleta, Calif., not only propose this radical idea, they have workable hardware to back it up.

According to the SMI researchers, present digital computers used in control systems are handicapped by the use of conventional transducers (which sense and convert physical variables into electrical input signals for the computer). Most transducers "measure" the physical variables by the gross effect of bil-

lions of molecules, and appear to have a continuous (analog) output. If transducers could sense these variables directly as a number, or count, instead of in a "continuous" manner, then no conversion from analog to digital form would be required to satisfy the input requirements of the digital computer.

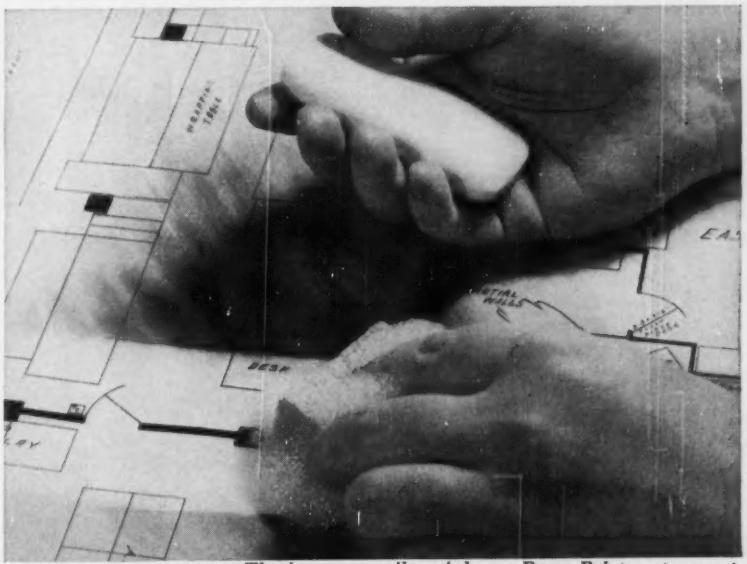
As the first step in designing an individual molecule counter, SMI has developed a vacuum-deposition technique which produces a thin film containing holes with diameters about the size of gas molecules (400 billionths of an inch). Molecules leaking through an individual hole can be counted.



Half of Navy's Biggest Thermoelectric Generator

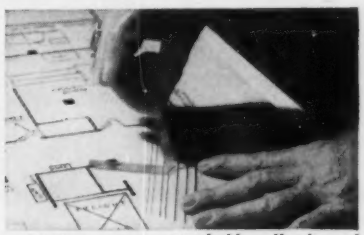
Fifty times more powerful than any heat-to-electricity unit built so far, Navy's new thermoelectric generator combines six different semiconductor materials to produce an output of 5000 w. Developed for BuShips by Westinghouse, the generator is an experimental unit that will help Navy to evaluate power-generating materials and fabrication techniques. Because thermoelectrics vary widely in their ability to withstand high temperatures, Westinghouse combined the six heat-to-electricity semiconductors in series from the hot side (1200 F) to the cold side (50 F) of the generator. This technique permits each material to operate at its most efficient temperature level. Shown here is one of the two 2500-w subgenerators making up the power package. Inner surfaces of the thermoelectric modules that form the cylinder are heated by burning kerosene; outer surfaces are water cooled.

DRAFTING TRENDS



A GLUTTON FOR PUNISHMENT. *The image, pencil or ink, on POST Polytex stays put. Won't rub, flake or peel off accidentally, yet can be erased. Duralar pencil lines bond to the surface readily. Soiled originals can be washed with water and detergent!*

New POST-perfected Polytex takes pen or pencil perfectly



TAPE TEST *proves remarkable adhesion of inked lines to the surface of POST 126 Drafting Film, lines which do not feather out or spread.*

You already know that drafting films offer the advantages of tremendous durability and dimensional stability. Now, thanks to an exclusive, precision process, POST offers a drafting film with superlative drafting characteristics. The surface of POST 126 Polytex is unmatched for ink receptivity, has a coating that stands up, erasure after erasure. Ink lines won't pull off when cellophane tape is applied firmly over them and then suddenly yanked off. Transparency is excellent.

If you prefer pencil, use a POST Duralar lead for permanence. Plastic-based Duralar lines actually bond themselves to the Polytex surface. Drawings won't easily smudge or smear . . . can even be washed with soap and water.

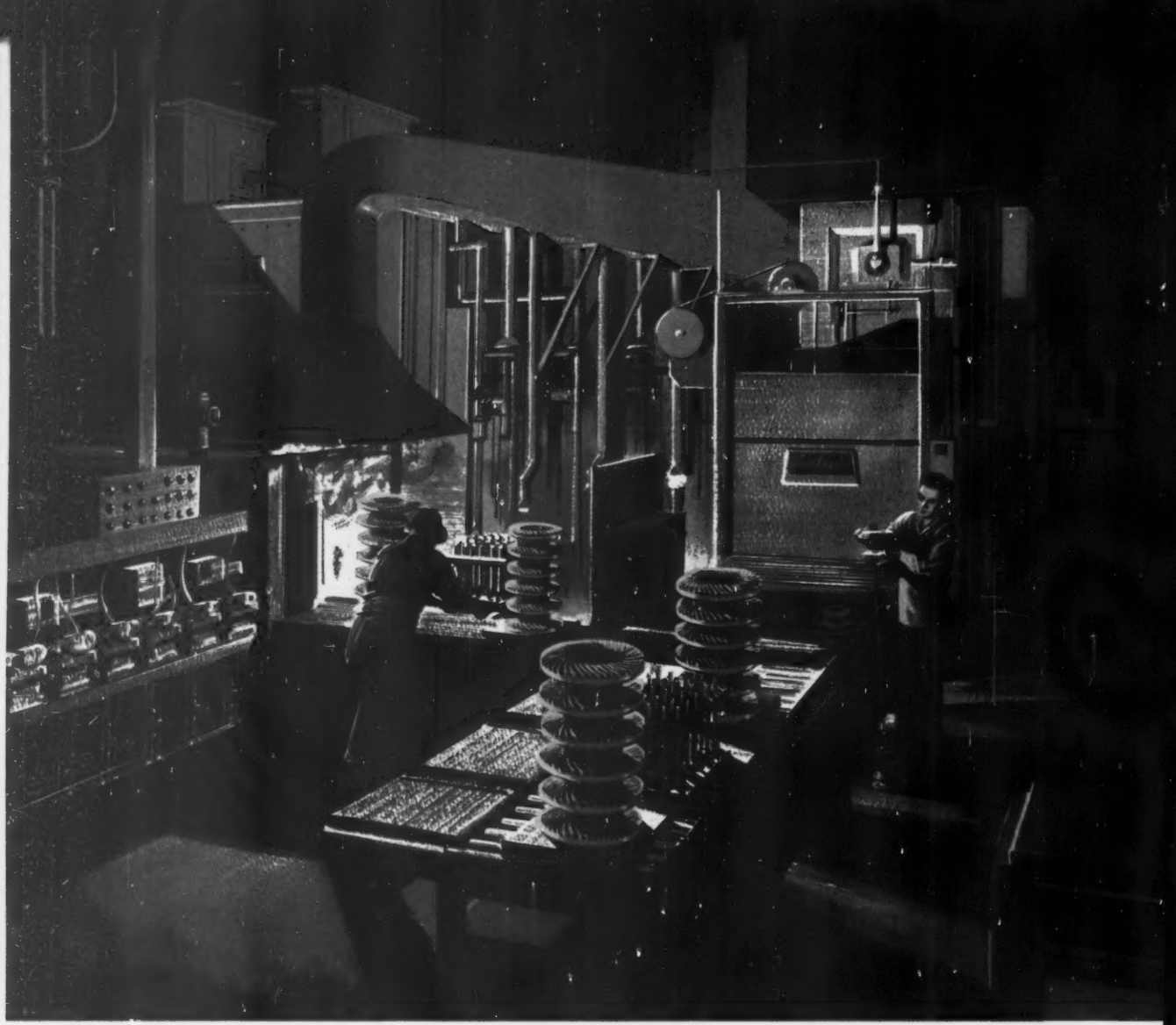
By using new Polytex, with DuPont Mylar base, you avoid the drawbacks which show up in some films . . . a drawing surface too slick to retain a pencil or pen line . . . too soft for use with hard pencil after erasures.

Enjoy the flexibility and long life of a drafting film with an ideal drafting surface. Try new 126 Polytex Drafting Film.

For more information, see your local POST Blueprinter, or write Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE



NEW GIANT AT WORK on Double Diamond Gears

This huge, continuous, carburizing, hardening and draw furnace now permits even greater instrument control in heat treating DOUBLE DIAMONDS for maximum wear resistance and load-carrying capacity. So far as we can discover no more efficient furnace could be installed to achieve the quality characteristics our gear customers have come to expect.

At your request, our gear engineers would be pleased to describe this process in greater detail and to explain, as well, what our recently expanded facilities can mean in terms of this pledge: "DOUBLE DIAMOND Gears offer the advantages of lower installed cost and economical and dependable service on the job . . . gears that do credit to your product and reputation."

EATON

AUTOMOTIVE GEAR DIVISION
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RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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May 26, 1960

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405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
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Looking for an Engineering Material that works two ways at once?

Check Urethane Elastomers

The big design engineering advantage of urethane elastomers is their combination of a high hardness range (from 60 Shore A durometer to 65-70 Shore D durometer) with high elasticity (elongation to 800%) which means a combination of working properties that gives you the structural strength of metals with the functional values of rubber.

Urethane elastomers are not merely another type of synthetic rubber; they are chemically-engineered materials with a completely new combination of properties. Properly designed urethane elastomer parts will outwear, out-perform other rubbers, plastics and many metals. Elastomers made with Mobay's Multrathane® line of chemicals have passed severe OEM tests for abrasion, impact and ozone resistance, flexing strength and wear properties.

If you have not yet investigated urethane elastomers for your design engineering requirements, get the facts from Mobay. Ask for the Multrathane Engineer's Manual.

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Dept. H-4 **Pittsburgh 5, Pa.**

Mobay supplies Multrathane chemicals and technology for manufacturing urethane elastomers.

MOBAY
First in Urethane Chemistry

Circle 413 on Page 19

a-c hydraulics offers one-way oil lines

Single-line hydraulic circuits (they'll need no separate return paths) are only one tantalizing prospect held out by a new fluid-power concept called "pulse hydraulics." Autolite's G. W. Lewis, manager of mechanical engineering research, says the system is analogous to an a-c electrical circuit—energy is transmitted by rapidly pulsating slugs, not direct oil flow. If the technique works out, efficiency will be high, says Lewis, and it's possible that mechanical flow-metering components may eventually be replaced by all-electronic controls with no moving parts.

the American car: 10 years of conservatism?

"Functionalism with thrift" will be the goal of automobile designers during the 1960s, according to Chevrolet's chief executive, Edward N. Cole. "Annual model changes will not involve massive and exotic changes, but will consist generally of refinements to improve the products and give the customer greater dollar value." The GM vice president also predicts that "cars will probably get shorter, maybe a little higher and much lighter through use of several lightweight metals. They will be easier to get into and out of —and will have more room for passenger comfort and trunk space." Cole does not expect the conventional piston engine to be replaced as the powerplant for American automobiles during the next 10 years. He does, however, see the possibility of gas turbines for trucks. "We are a long way from the gas-turbine car," he said, "or, for that matter, one which rides on a stream of air or on the electrical energy from a fuel cell."

metrologists find one part in ten million

For precision production in the space age, demands for production accuracies of one part in a million are becoming more insistent, and even closer tolerances may be required as the new age gets underway. To meet these needs, the National Bureau of Standards, aided by a group of private companies, is engaged in research in basic metrology. They have traced dimensional instability in present-day gage blocks to structural changes which occur during hardening. But annealed blocks are too soft to use, and harder materials are too expensive. Years of research have led NBS to nitrided, carbonitrided, or cyanided case-hardened blocks. Some of their new blocks now exhibit a growth of only 0.0000002 in. per year, and will be commercially accurate to one part in ten million.

"Q" is for more and better

Industry's first "Q" awards—"for quality and quantity production to combat increasing foreign competition, inflation, and complacency"—were presented recently by their originator, Packard Bell Electronics Corp. Recipients: 49 employees and one supplier of the company. Robert S. Bell, P-B president, says the awards are intended to be "an incentive in the economic war of workmanship, similar to the 'E' awards given by the Navy during World War II." He has hopes that the "Q" program will be adopted by industry nationally as a production symbol for "Made in USA."

ceramic-metal "alloys" promise new high in strength

Ceramic fibers with tensile strengths ranging to 3 million psi are being combined with metals to produce new "unbelievably high-strength materials," according to the Cleveland research firm, Horizons Inc. Dr. Eugene Wainer, Horizons' director of research, says the manufacturing process involved is similar to that used in making combination glass fiber-plastic rocket nozzles. One of the new "alloys" currently under evaluation is made up of nickel-chrome alloy combined with aluminum-oxide fibers. Al_2O_3 fibers were chosen because they can be wrapped around an exceedingly small radius without fracturing, and because they retain about half of their high tensile strength at the melting point of the nickel-chrome matrix. Horizons has already licensed a major company to produce ceramic fibers in quantity.

needed: death certificates for consumer products

Although most companies keep accurate records on production, or "birth" rates for their products, many lack information on useful life or "death" rates. Professor Cowan, of the University of Michigan, thinks companies should step up their efforts to determine the life-span of consumer products. Knowing how long products last after they are sold is essential in determining future sales patterns. In a recent survey, he said, the average life of vacuum cleaners was 11.4 years, washing machines 10.6 years, and television sets 9 years.

more about a weighty problem

Workers in the field of gravity research often liken their position to that of missilemen 20 years ago . . . ideas and pet projects are "too far out." Nonetheless, much dedicated effort is being put forth, and at least two organizations have been set up to act as clearing houses of information. One of the latest pieces of research has to do with the ultimate control mechanism for gravity. Charles Tilgner Jr., Grumman Aircraft's chief aeronautical engineer, believes that the control mechanism will be an electronic device . . . capable of imposing a force on the mass of a body so that it permeates the body and acts on each particle with a force proportional to its mass. This would make possible infinite acceleration (or deceleration) of the most sensitive mechanism, providing that the force was uniform and properly oriented.

research help for metal cutters

Predicting machinability of metals—*before* first samples have been machined—is the goal of a University of Michigan research project. Working under a $37,000 National Science Foundation grant, Prof. Joseph Datsko will examine known physical properties (mechanical, thermal, and metallurgical) of the new metals, try to devise a scale or equation that will give fabricators advance information on just how the material will act when being machined into useful products. Next step, says Prof. Datsko, is advance predictions on ease of forming, welding, and casting. If the study works out, it will be a bargain: The U. S. government spent a million dollars during the 1950s determining (by machining tests) the cutting behavior of titanium.

Design Data on Resilient Clutch Facings

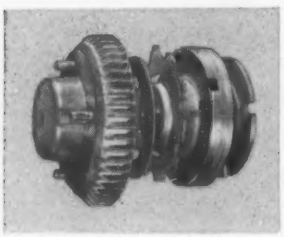
#9

MORE CLUTCH PROBLEMS SOLVED BY ARMSTRONG RESILIENT FACINGS

Clutches are used in such a wide variety of applications—from delicate laboratory instruments to heavy road graders—that one clutch facing obviously could not be expected to fit every application. However, great advances in compounding new resilient friction materials have broadened the usage of resilient facings to include almost every type of application.

Here are just a few examples of how Armstrong resilient facings have solved specific clutch problems. These examples are certainly not exhaustive. They are merely intended to indicate the extreme versatility of Armstrong resilient friction materials.

Controlling wear on aluminum



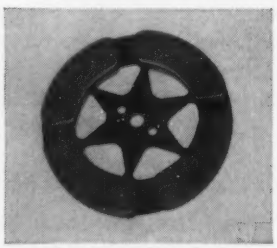
Thermo-modulated fan drive

Many friction materials damage opposing surfaces in clutches where aluminum or other lightweight metals are used. Engineers faced this problem in a fan drive designed to adjust fan speeds to engine cooling demands in trucks and buses.

The friction material had to meet three requirements: deliver enough torque capacity to engage positively while immersed in silicone; resist 250°F. temperatures for long periods; and, of greatest importance, eliminate scoring of opposing plates.

Of the materials tested, only one met all the performance requirements—Armstrong FM-45. And this fiber friction material also gave a saving of 25% in cost.

Instantaneous engagement and braking



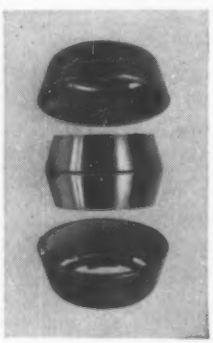
Sewing machine clutch

The clutch in an industrial sewing machine must move from 0 rpm to 3600 rpm in 1/10th of a second . . . as often as 40 times a minute. At times, the clutch is purposely slipped to permit slow speed operation.

This application requires a friction material with virtually instantaneous engaging and braking action. Armstrong FM-88 was selected for the job, because it can transmit torque . . . or break it . . . instantly. And FM-88 also provides quiet operation, even when the clutch is purposely slipped for slow-speed operation.

Facings of FM-88 usually last for several million engagements. It is an ideal clutch facing material for such things as coil winders, tappers, and reamers.

Reducing vibration and chatter



Double-cone clutch

Tapping machines require clutches that can transmit power efficiently under widely varying conditions of facing pressures and speeds.

The double-cone tapper clutch shown here has friction facings of Armstrong NC-733, a resilient material that can operate either dry or immersed in oil. NC-733 provides smooth, quiet operation, without the vibration or chatter that could break taps and spoil precision work.

This facing delivers the torque capacity needed for tapping holes up to 1½" in diameter in steel plates. And it picks up the required torque instantly at any tapping speed.

In addition, NC-733 is so sensitive to the performance of the tap that the operator can immediately detect a dull or overloaded tap, even where facing pressures are low.

Wet clutch improves performance

Lift-truck clutch

Heavy duty lift trucks impose severe demands on clutches. In the stacking operation, the engine runs at high speeds to operate the hydraulic hoist while vehicle movement is controlled by clutch slippage. This operation, termed "inching," results in severe clutch slip loads.

One manufacturer recently introduced a new oil-bath clutch for use on his lift trucks. The clutch is faced with NC-733, an Armstrong resilient friction material.

This new oil-bath clutch has eliminated a serious heat build-up problem. And the NC-733 clutch facing gives smooth inching and better performance than previous materials. Wear has been reduced on the pressure plate and flywheel, and the facings last 1000% to 2000% longer than those on the previous clutch.

For assistance in solving a problem involving friction materials, send complete details of your application to Armstrong Cork Company, Industrial Division, 7205 Dean Street, Lancaster, Penna.

Armstrong RESILIENT FRICTION MATERIALS

1860-1960 Beginning our second century of progress

Close-up of the technician:

Engineering Semipro?

2-His expectations: Problem for managers

HOW does the engineering technician look at his career possibilities? His job attitudes, expectations, and frustrations—which obviously affect his productivity—offer hints on how engineering administrators can set up and carry out rational policies for handling such technical support personnel.

To sample expectations of future technicians — i.e., technicians in training — authors of the Harvard study questioned students from a leading technical institute.* Responses provide some insight into the problems these men are likely to create for their engineer-bosses once they get into the field. The self-image of the typical student also gives a part answer to a longer-range question: Are technical institutes realistically indoctrinating their technician students for careers in industry?

Student expectations—understandably on the high side—are likely to suffer when the graduate faces day-to-day realities of the on-the-job situation. Realizing that frustrated expectations pose potential problems for administrators, the Harvard task force next interviewed technicians who work in the research laboratory of a large electronics corporation. Results of these talks — although they lack complete statistical validity —highlight some of the dilemmas practicing technicians face in adjusting to life in an industrial environment. Contrasted point for point, the two surveys build a picture of a technician who begins work with strong initial expectations for achieving engineering status. Eventually, in many cases, he faces realities which don't coincide with his expectations.

Pursuit of a Title

Among the technicians in training, one attitude is highly prevalent: They will enter the industrial world with strong expectations of achieving engineering status. They don't appear to have a clear understanding of themselves as something distinct from professional engineers. It is clear, too, that despite differences in emphasis in industrial and engineering-technician study programs, students in both groups expect the same treatment from industry.

In some instances, there is recognition of lower status by the technical students — for example, in areas of supervision, admission to professional societies, and in personal objectives. But the theme of equal qualifications and like interests with the professional engineer predominates. Quite obviously, the engineering technician sees himself as

*Wentworth Institute, Boston

This article, outlining technician attitudes, is the second in a series based on a complete report: *Managing Technician Manpower*, available from Technical Manpower Associates, P. O. Box 158, Scarsdale, N. Y.

pressing the "engineer barrier" in his daily work.

In contrast, very few practicing technicians expect to earn the engineering title. While they state a desire for more education (and many are taking night-school courses), few aspire to more than the junior-engineer rank. Most cite the difficulty of holding down a job and earning a degree at the same time. Some admit that further schooling is simply too much trouble — especially if they're satisfied with what they're doing.

Although many are attending classes, some practicing technicians seem to feel that promotion to junior engineer calls for "sweating out years with the company rather than additional education." The majority aren't graduates of technical institutes, but they don't think this matters. They believe that practical experience is the equivalent of a technical-institute education. However, many concede that their experience, as it is shaping up, is not the kind needed for junior-engineer positions.

They admit the possibility of technical-institute graduates grabbing off junior-engineer slots, and some think this is unfair. They feel that the newer graduates will freeze the "old hands" at their wage-earning levels. Nevertheless, most think that the need for technicians is so great that there is room for everybody.

Supervision: Mixed Attitudes

The majority of technical students indicated they expected to be supervised by engineers. The engineering-technician group indicated very high expectations in this regard, while the industrial technicians were less certain.

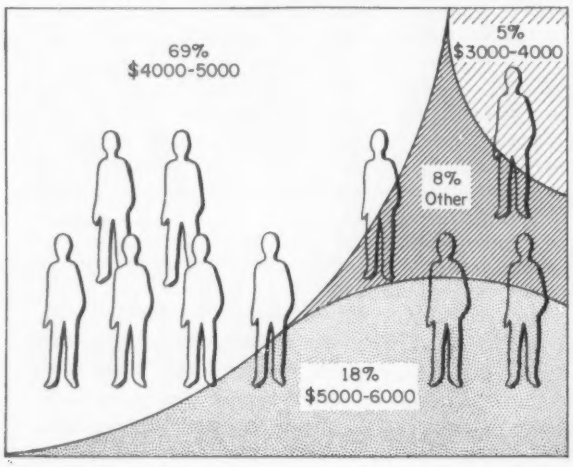
The manner of supervision served (perhaps more than any other factor) to divide practicing technicians into "satisfied" and "dissatisfied" categories. Those happy with the arrangement generally worked for one engineer. The dissatisfied technician was usually a member of a pool and his assignments were sched-

Technicians Look at the Societies

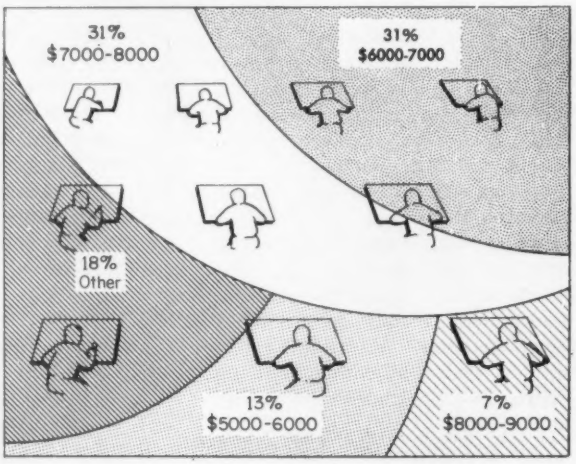
Technicians should be members of professional societies, student technicians all agree. But opinion is divided on the kind of society that would best serve their interests. Three common proposals are that technicians:

- Join engineering societies at junior or associate member level. Favored by engineering technicians, the plan hinges around the argument that "since engineers plan the projects and technicians carry them out, the two groups depend on each other and, therefore, must freely exchange ideas."
- Join technicians' societies only. This approach is popular with industrial technicians who feel that, while they are almost equivalent to engineers, they are also skilled craftsmen in their own right.
- Join both engineering and technicians' societies. Usually suggested by engineering technicians, this idea is the least popular of the three. Engineering technicians want to join with the engineers, industrial technicians prefer to band together. Few see benefits in joining both types of societies.

$ $ $ Engineering Technicians: How Much Pay Do They Expect? $ $ $



After graduation . . .
Student technicians were asked what they expected in future (annual) pay. Their estimates of starting salaries and pay after five years averaged out to about the going wages.



Five years later . . .
Although estimates covered a wide span, all agreed on one side issue: They expected to be on salary, not on an hourly rate—giving them a status jump on production workers.

uled by an engineer who acted as an administrator for other engineers. The senior technician in the group transmitted the administering engineer's orders.

In describing his work, the typical satisfied technician stressed personal relationship with his engineer boss and felt that the engineer did not bar advancement. He talked about "the range of problems; working pretty much on his own; and being treated like a specialist, not like a production worker." Nevertheless, even in the satisfied group, some technicians said that engineers "don't know what to do with a technician, and therefore never get to see how much he can do."

The majority of the dissatisfied technicians felt that engineers and scientists were impediments to full use of a technician's talents.

Unions: Not Popular

Student technicians had no apparent objection to joining a union. Significantly, the great majority preferred to join the same bargaining unit as the engineers. If they couldn't, there seemed to be little real interest in joining with any other group.

Sentiment among industrial-technician students leaned slightly toward the skilled-craft bargaining units, but this fact probably indicates the emphasis placed on skill rather than any positive identification with skilled craftsmen. There was almost no interest in joining a bargaining unit representing production or clerical workers.

All practicing technicians surveyed were members of the same union, a union set up to represent production workers. Most had gone as high, or almost as high, as the job-classification system allowed. They all agreed that the system was bad because it placed them on the same basis as production workers. They insisted that their jobs required a great variety of skill and exercise of judgment, that the classification system was never set up to handle their type of job, and that the union was a strait jacket to advancement.

All want to go on salary, stop punching time clocks, and — most important—become junior engineers. Members of technician pools seemed

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Technician Curriculum: Stress on the Fundamentals

First Semester

Course	Credit hours
Mathematics	5
Physics	4
Machine Shop	4
English	5
Drafting	2

Second Semester

Course	Credit hours
Analytical Geometry	5
Physics	4
Kinematics	3
Metallurgy Lab	2
Machine Shop	4
Drafting	2

Third Semester

Course	Credit hours
Calculus	3
Thermodynamics	3
Thermo Lab	1
Mechanics and Strength of Materials	5
Str. of Matl. Lab	1
Machine Design	3
Industrial Management	3

Fourth Semester

Course	Credit hours
Internal Combustion Engines and Lab	4
Electrical Circuit Theory	6
Electrical Science Lab	2
Machine Design	3
Tool Design	2
Pattern Shop	3

High-school graduates take these courses at one institute, earn mechanical engineering technology certificates. More comprehensive than vocational-school curriculums but briefer than engineering programs, technical-institute courses are designed to prepare technical support personnel for specialized areas within engineering. Emphasis is placed on applying basic math and science.

especially anxious to show what they could do, but all agreed there was little chance of achieving recognition without a change in company administrative policies. None foresaw any change, however, and all cited security of the job as the chief reason for sticking at it.

Technicians working directly for one engineer (rather than being assigned to a pool) offered a different slant: They felt the company was helpless to do anything about either wage or job-classification problems because they made a small group in a large union. Significantly, however, they did not feel that a separate technicians' bargaining unit was the answer. In fact, a frequent statement was "We don't believe in unions." For this group, chief reason cited for staying on the job was "It's important work." All are looking forward to a chance to get out of the union into salaried ranks.

Wage Aims: Realistic

Student technicians seem to have a fair grasp of going wages in the area surveyed: They expect a starting salary of $4300 per year; after five years they expect to be making $6500. Industrial technicians in training think of themselves as skilled craftsmen as well as junior engineers, and their wage expectations are initially higher. Engineering technicians, however, expect to advance faster, at least in early years.

Although they feel they are not getting a square deal from management on wages, the practicing technicians tend to blame their troubles on the union. The satisfied technicians—those who work directly for one engineer and consider their jobs important—average $2.70 per hour. The dissatisfied technicians—those who work as part of a technician pool and consider their jobs as "just production jobs"—average $2.60 per hour.

All felt their wages were low, but none planned on leaving for this reason. Rather, they appear to have adopted a hopeful watch-and-wait policy, although few expect any changes in their bargaining position.

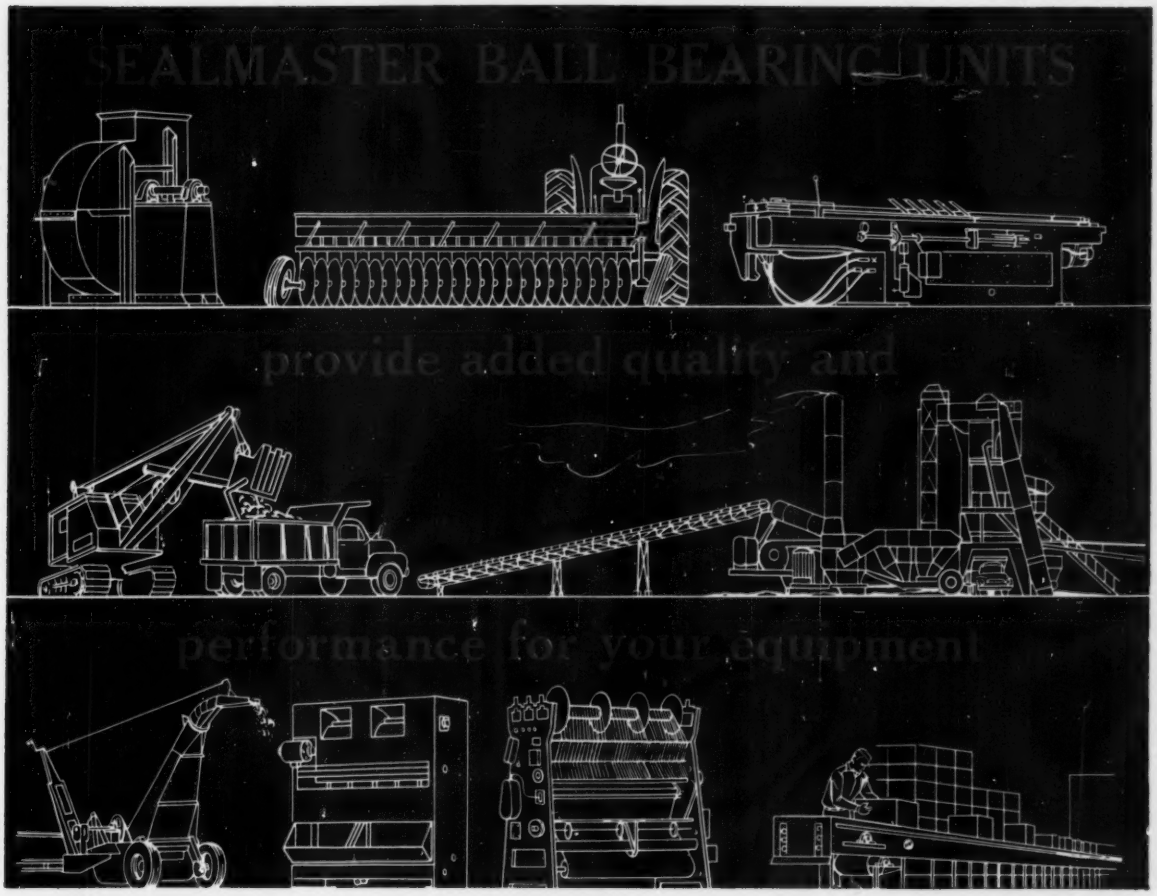
Both student and practicing technicians evidenced a strong desire for a salary, rather than an hourly rate. They seem to attach a feeling of professionalism and recognition to this form of pay. In addition, it separates them from the production workers.

The technician's point of view—examined in this article—is one of the factors which determines his worth as a contributing member to the over-all engineering effort.

The next article in this series summarizes modern management thinking on the basic question: "Technician — Professional or production worker?"

Turbojet Soups Up Helicopter

Significant improvement in hovering and flight performance of helicopters can be achieved without major changes by a technique now undergoing testing. Engineering studies by Kaman Helicopters Inc., Bloomfield, Conn., show that a jet boost system added to the Navy's newest turbine-powered 'copter, the Kaman HU2K, increases speed by 40 per cent, lift by 20 per cent, and range by 17 per cent. The booster engine, GE's J85 turbojet is a production model which could be added to new helicopters at relatively minor cost. The proposal calls for a booster jet to be pilot-controlled for thrust in horizontal, vertical, or some intermediate direction.



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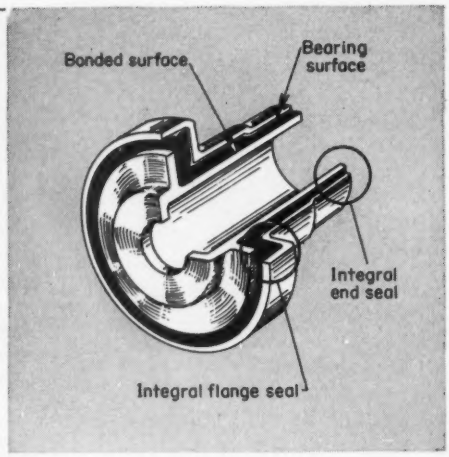
built like a bearing . . .

No-Windup Bushings Deaden Road Shocks

High-frequency vibrations generated by rough road surfaces may not plague motorists much longer. Rubber bearings, designed to cushion and quiet the ride, have tested out well, may soon replace rubber bushings in automotive suspension system control arms. Permanently lubricated, the new bearings have practically flat torque vs. deflection characteristics over a 360-degree range.

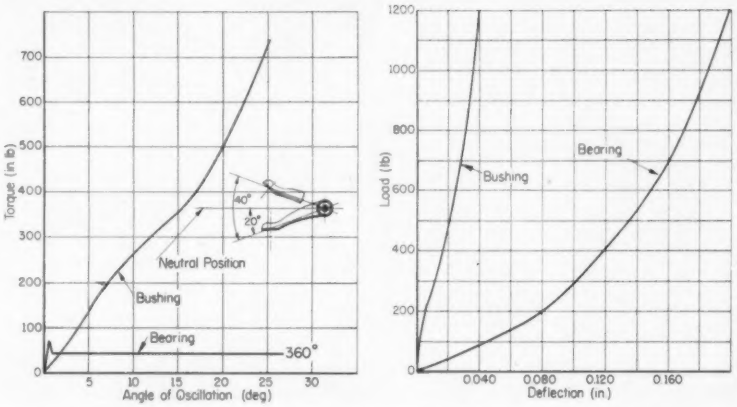


Control-arm vibrations in the front-to-rear direction have never been adequately handled, report spokesmen for Clevite Harris Products, Milan, Ohio. They aren't damped by automobile tires, springs, or shock absorbers, and conventional rubber bushings in control arms aren't really designed for the job. Now, however, a new type of permanently lubricated rubber bearing (developed by CHP and called Clevbloc) has been designed to cushion axial motion while the control arm flexes.

The bearing is manufactured in two parts—a journal assembly, with rubber bonded to the inner metal face, and an outer metal tube. A special temperature-stable lubricant is permanently sealed between the bonded rubber and the outer tube, allowing the tube to slide on the lubricated rubber face.

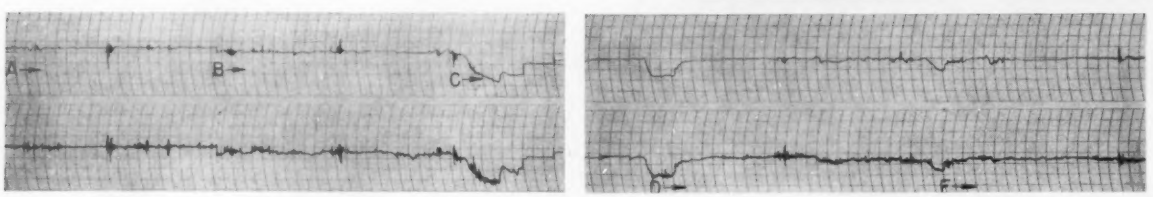
Advantages claimed for the system include: Exceptionally long life, reduced road-noise transmission, constant torque, tuned lateral damping, reduced harshness and shake frequency.

Besides improving ride quality, all eight of the new bearings in the control arms can be replaced in 20 minutes—about one-tenth the time required to replace bushings.



Restoring torque, generated as the control arm deflects through an angle, levels out at a constant value as the lubricated rubber slips in the outer tube. Free from torsional windup, the bearing can accept oscillations up to 360 degrees. In comparison, the conventional bushing builds up to a high torque value before slipping. Less stiff than the conventional bushing under axial loads (right), the bearing provides the desired fore-and-aft control-arm compliance.

During road tests, rubber bearings were used in the test auto's right front control arms, standard bushings in the left front arms. Four Metrisite linear-motion transducers (built by Brush Instrument Div., Clevite Corp.) attached to the frame with sensing arms resting against plates mounted on the control arms, picked up axial control-arm vibration.



Upper trace shows action of control arm mounted on the new rubber bearing. Lower trace shows control-arm action on standard bushing. Letters indicate: A, Ride quality along bumpy road at 40 mph, upper control arms; B, Same as A, lower control arms; C, Sudden braking; D, Braking and slowing down from 40 to 25 mph on smooth highway; E, Bump in road on smooth highway. Full-scale deflection of the recorder-pen corresponds to 0.1000-in. axial motion.

Pioneer V: Remote Control From Eight Million Miles

WASHINGTON — Outward bound, some 8 million miles from earth in the cold vacuum of outer space, the U.S. Pioneer V artificial planet began broadcasting loud and clear early this month from its powerful 150-watt transmitter.

The event not only marked a new high in U. S. technological achievement, it put this country in undisputed first place in space exploration. The sheer volume of valuable scientific information being radioed back to earth from Pioneer V will keep scientists busy for months. Already, the probe has overturned well-entrenched theories concerning solar-flare effects and the extent of the earth's magnetic field.

Good Mileage on 5 Watts . . .

Since launch at Cape Canaveral on March 11, the 94.8-lb probe has been telemetering scientific information daily via a 5-watt transmitter. Early on May 7, when it was apparent that the 5-watt unit had nearly reached its transmission limit, it was decided to attempt to energize the 150-watt transmitter. This called for a three-step sequence. First a signal was sent to the spacecraft from England's Jodrell Bank (Manchester) radio telescope which put power into tube filaments through a current-limiting resistor, thereby warming the filaments for about one minute. Six hours later, the first step was repeated and a second command was sent which removed the current-limiting resistor and supplied full filament heating for several minutes. When it was apparent that the circuits were responding properly, Manchester sent the final command in the three-part sequence. This energized the 150-watt transmitter as well as an electric converter serving it, both of which had remained idle in the "hard" vacuum of space.

Small, but Loud . . .

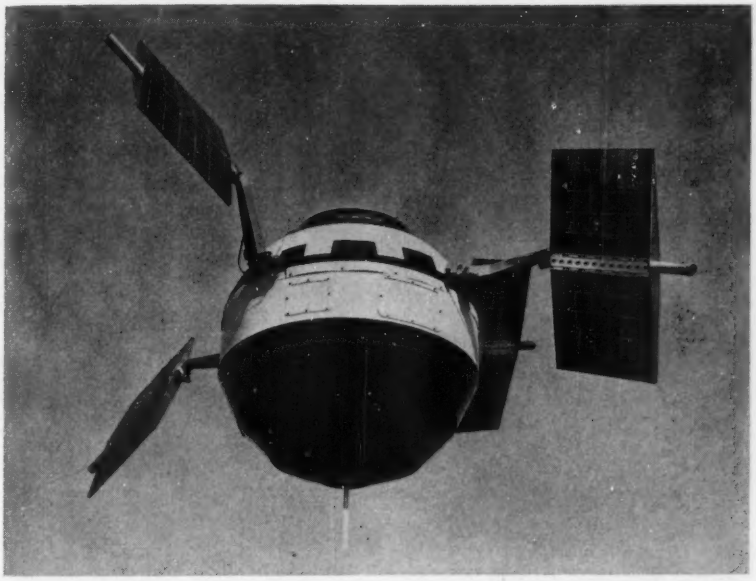
Contained in a 5 x 7-in. package, the 150-watt unit consists of two amplifier tubes—about the size of those in ordinary household radios —along with capacitors, coils, and resistors. It weighs 5 lb.

Power for the probe comes from 4800 solar cells in four arms jutting from the 26-inch spherical package. The solar-cell output constantly charges 28 chemical batteries, which are about the size and shape of standard flashlight batteries, but much more powerful. These in turn power more than 40 pounds of electronic equipment. Because of the power drain, the 150-watt transmitter is being operated only 2 to 3 minutes every 6 to 8 hours.

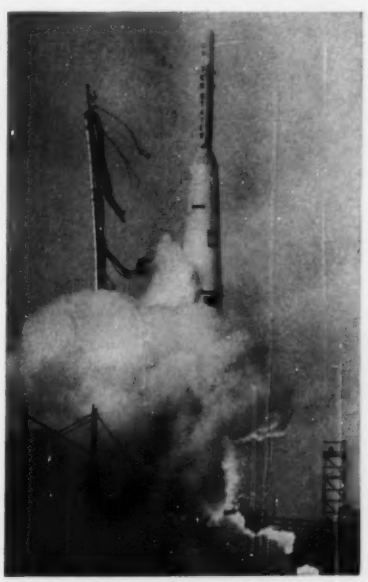
Manchester can now receive data at the rate of either 8 or 64 bits per second. The South Point, Hawaii, tracking dish will continue to command the spacecraft at a rate of just one bit per second.

According to NASA, it is impossible to predict how long the spacecraft will continue to relay information. In recent weeks, a minor component failure has been noted and compensated for. Also some slight deterioration in the batteries has been observed, possibly the result of leakage in the vacuum of space.

To date, the probe has returned more than 109 hours of data on cosmic radiation, charged particle energies, and magnetic phenomena.

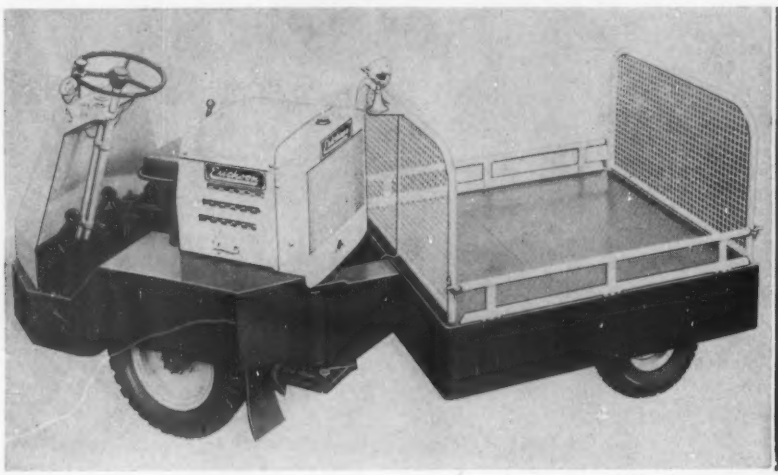


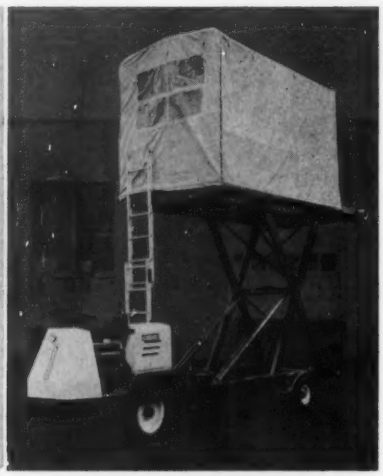
Orbiting between earth and Venus, Pioneer V carries the familiar paddlewheel arrangement of solar cells to power its instrument payload. The 26-in. diameter sphere is traveling a path some 75 million miles from the sun, at an average speed of about 70,000 mph (Earth's speed is 66,000 mph; Venus' about 78,000 mph). As the probe continues in its first swing around the sun—to a maximum distance of about 186 million miles from earth—radio contact will undoubtedly be lost. However, scientists are hopeful that contact will be re-established sometime in 1963 when Pioneer V will pass within 50 million miles of earth. Closest approach of the probe, which will occur "sometime during the next decade," is estimated at several hundred thousand miles. Predictions are relatively uncertain because scientists are not sure how Venus will affect the orbital path of the vehicle.



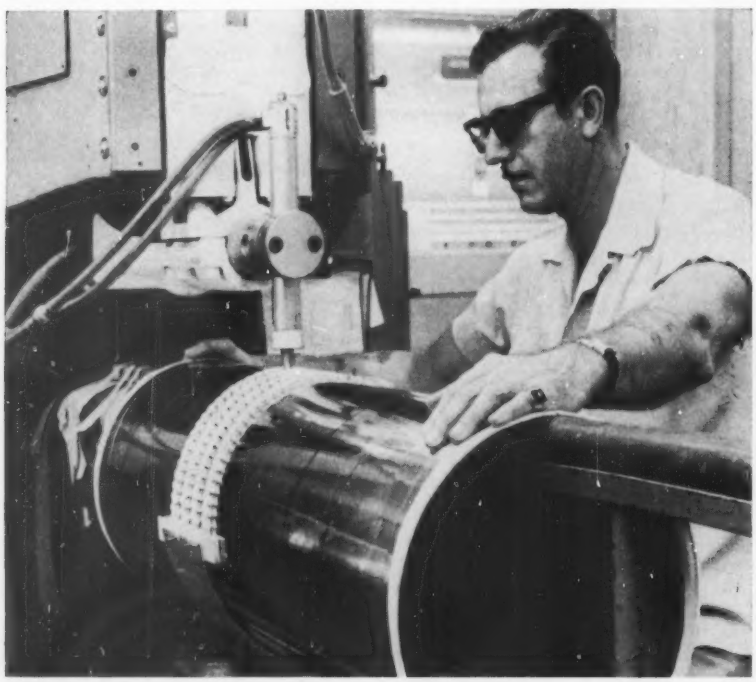
Old reliable: Launching vehicle for Pioneer V was built around the Thor IRBM, a well-proved Air Force weapon that has experienced surprisingly few developmental problems. Three-stage configuration was used, and at burnout, Pioneer was traveling within 150 mph of its planned velocity.

Truck Articulates, Elevates





Effect of four-wheel steering is achieved with an articulated pivot in a small tractor designed for a variety of light utility jobs. Capabilities range from use as an elevated platform to short hauling trips. The power package itself is a 32-hp production model equipped with a four-speed transmission; the load-carrying unit can be designed to suit individual customer requirements. The designers, Erickson Power Lift Trucks Inc. Minneapolis, claim greatly reduced wear for their simplified steering system as a result of the articulated joint. A further advantage is greater maneuverability.



Ultimate Tensile Strength—300,000 psi

Paper-thin stainless steel is helping to contain the tremendous force developed by the latest rocket motors. Experimental fabrication conducted by Ryan Aeronautical Co., San Diego, Calif., shows that many layers of stainless spotwelded together are stronger than a single layer of plate forming a solid cylinder wall. The high tensile strength was achieved with AM-355 stainless sub-zero cooled, cold rolled, and tempered. Previous high in rocket-case strength was 240,000 psi, achieved with low-alloy steel rolled or spun into a single-wall cylinder.

Natural Gas Sought From Irradiated Coal Char

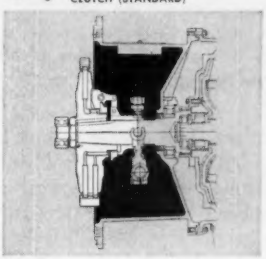
NEW YORK, N. Y.—A material intermediate between coal and coke may provide a future source of "natural" gas as a result of a broad program of research going on at Columbia University. As part of a research program in radiation-promoted chemical kinematics, University scientists, financed by the Consolidated Natural Gas System, are attempting to convert coal char to methane.

Coal char is coal from which the most volatile ingredients have been driven off by heat. Coal is plentiful, and modern mining methods have made it cheap. Also, the largest coal fields are located near major gas consuming cities, so an economical process for making gas from coal char would be an important achievement. Preliminary experiments have been encouraging.

University professors explained that the ability of gamma rays to excite molecules is the key to the research program. Methane, composed of four hydrogen atoms and one carbon atom, could be formed directly if the elements could be intensely agitated by radiation. The technique for accomplishing this is

NEW From TWIN DISC . . .
Single-Stage Torque Converter
WITH DISCONNECT CLUTCH

◇ "C" WITH FRONT-END DISCONNECT CLUTCH (STANDARD)



◇ "O" WITH OVERSPEED OR BOOM-LOWERING FREEWHEEL

◇ "G" WITH 2:1 RATIO OUTPUT REDUCTION GEAR

IN THE APPLICATION of single-stage torque converters, Twin Disc's new *Model C* units provide considerable design flexibility. These clutch-equipped converters are offered in three input torque capacities: 350 lb-ft (1300 Series); 450 lb-ft (1500 Series Standard-Duty); and 650 lb-ft (1500 Series Heavy-Duty).

All Model C units feature an 11" front-end disconnect clutch—single-plate on the smaller series; two-plate for capacities above 350 lb-ft. Both clutches are mechanically actuated types with driving rings that fit standard SAE over-center flywheels.

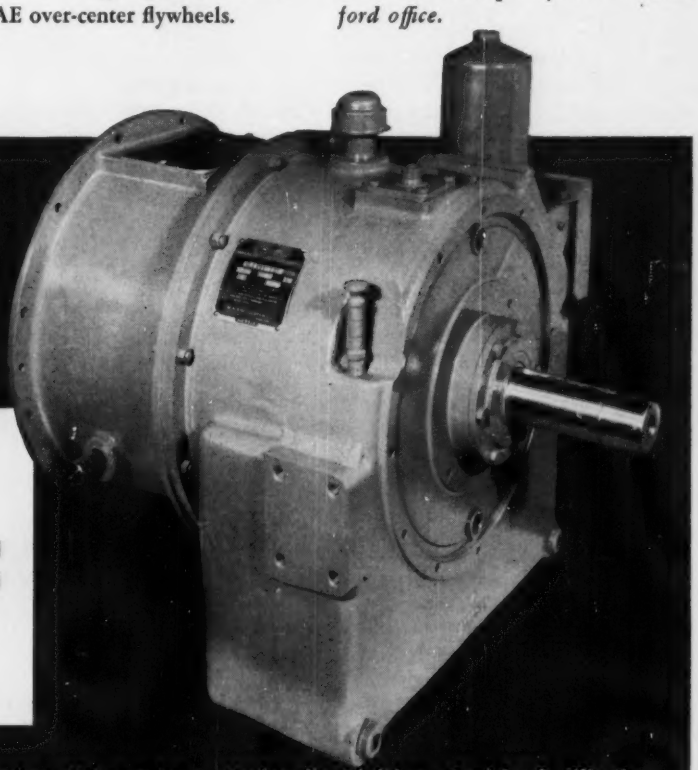
OPTIONAL
Boom-Lowering Freewheel

For the shovel and crane industry, Twin Disc has designed a special converter—*Model CO*—with a cam-and-roller freewheel between the impeller and the turbine. This permits the converter to function as a straight mechanical drive whenever the output shaft is driving. As the boom begins to fall of its own weight, the freewheel locks the turbine to the impeller, making engine friction horsepower available for braking.

OPTIONAL
Output Reduction Gear

For installations using high-speed engines but requiring lower output shaft speeds, Twin Disc can furnish a 2:1 ratio reduction gear. It bolts to the rear of all Model C and CO converters and is capable of carrying output shaft side loads. The gear can be mounted in the field without design change.

New Bulletin 510, containing engineering data on 25 models of Twin Disc Single-Stage Torque Converters, is available on request from our Rockford office.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • Hydraulic Division Rockford, Illinois

Circle 417 on Page 19

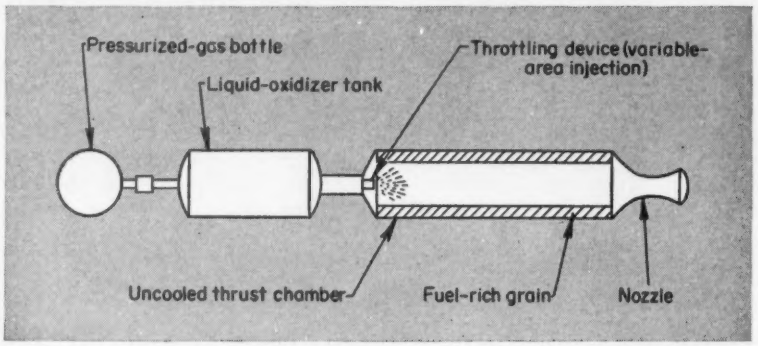
a scientific puzzle for which a practical solution is now in sight. Experiments will use radiation from a source of cobalt-60, which yields about 3000 curies of electromagnetic energy released by the disintegration of 10^{14} atoms every second. Eight pieces of cobalt will be immersed in 16 ft of water in a concrete building.

Head of Columbia's school of engineering, Dr. Dunning, said, "American industry is sometimes criticized for not putting enough emphasis on basic and long-range research, but here [referring to the grant] is a notable example of technological statesmanship.

Natural gas reserves are adequate for many years, but costs of discovering and developing new reserves spiral upwards year after year. Since natural gas has compelling advantages for many purposes, an economical substitute for the natural product must be sought. One line of research is the use of atomic radiation to convert other substances to gaseous fuels by catalysis, or molecule building.

Other departments of the University are expected to make use of the cobalt source, too. By bombarding chemical catalysts with radiation, we hope to make them more active, said one professor. This way, gasoline, acids, and plastics could be produced more economically.

The Solid-Liquid Rocket: End of an Argument?



Simplicity of the hybrid—it contains few moving parts—is an important source of its reliability. The motor is safer to handle than an all-solid propellant because its fuel grain is relatively inactive and the oxidizer system is handled separately. Oxidizer and propellant are storable in −65 to 160-F temperatures.

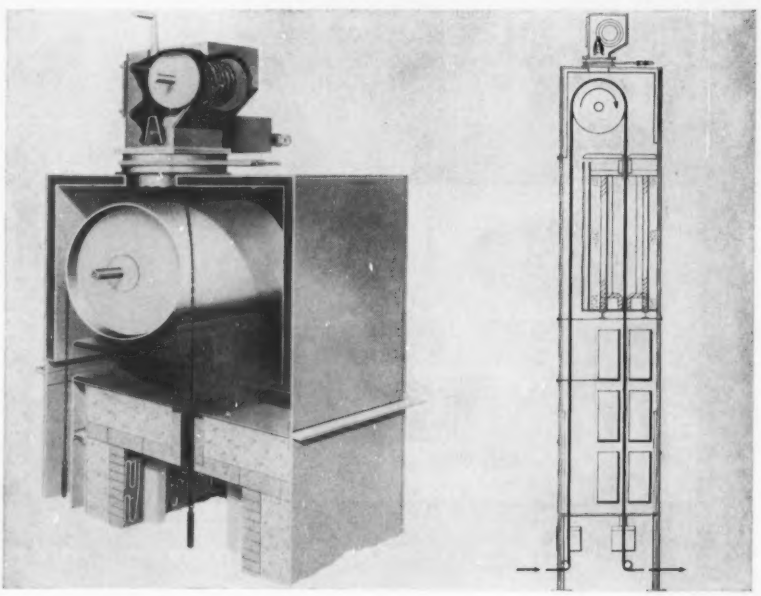
REDLANDS, CALIF. — The wide difference of opinion between proponents of liquid and solid-fuel rockets may be narrowed by a brand new system that combines features of both. Scientists at Grand Central Rocket Co. and the Marquardt Corp. have pooled their talents to produce a hybrid motor that uses both a solid fuel and a liquid oxidizer. Thirty-two motors have been built to date, and tests have been highly successful.

The hybrid consists of three major parts: A liquid oxidizer storage tank, the solid propellant grain, and the throttling device. Gas is transmitted under pressure to force the liquid oxidizer into the combustion chamber. This brings about hyperbolic ignition and stable burning of the solid propellant grain in the chamber. An "off-on" control system in the liquid-oxidizer line permits thrust and maneuverability of the rocket to be varied. Thus, in contrast to the solid motor and the cryogenic system, the hybrid rocket can change thrust level on command and is capable of modulation from 0 to 100 per cent thrust.

Scientists at Grand Central predict that hybrids may soon be used for orbital correction motors, retrorockets for soft lunar landings, and to provide the limited and variable "g" forces required for space operation with human payloads.

Parched Electric Furnace Cuts Annealing Costs

Almost dry atmosphere of an electric furnace may do away with pickle lines in bright-annealing plants and cut the cost of stainless-steel strip substantially. This atmosphere, with a dew point of −60 F, is 99.995 per cent dry, and prevents scale formation. Hence there is no need to pass the strip through pickling baths for scale removal. The strip is fed into the vertical furnace in an inverted "U" after cold rolling. As it enters the furnace, it is heated to annealing temperature by direct radiation. After heating, the strip goes through a cooling chamber, where high velocity hydrogen or dissociated ammonia is passed over it. At 2000 F the furnace can handle up to 60 ft of material per minute.



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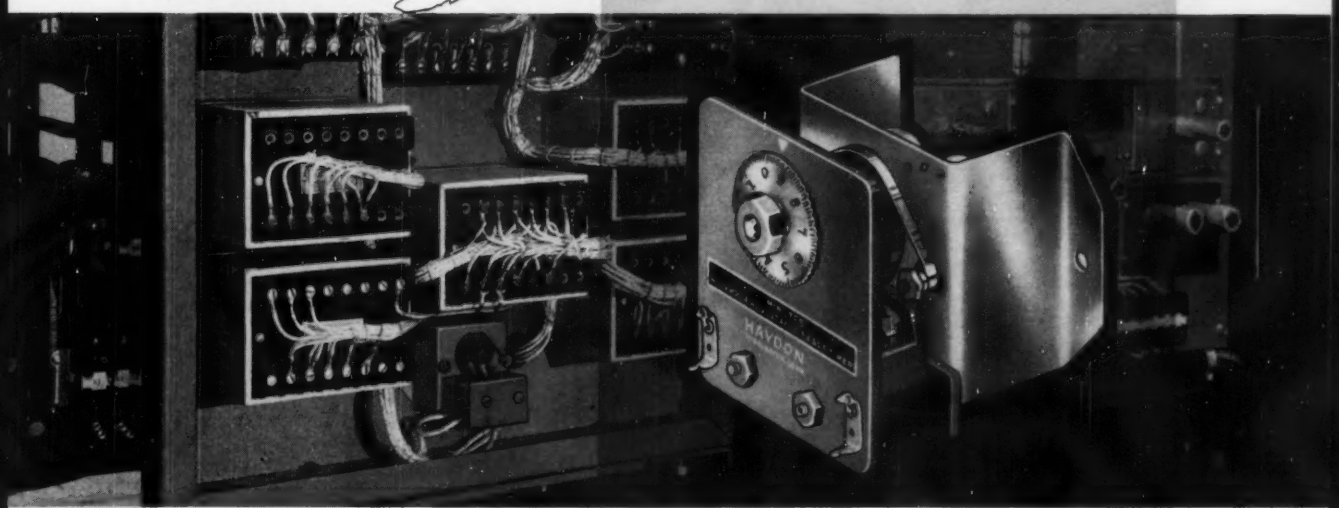
Timing performance like this is available for your applications. For additional information on Haydon Timing Motors and Devices, write for our General Catalog.



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The Haydon Timing Devices used on Reliance V☆S Drives are standard DA-21 Time Delay Timers . . . with special modifications developed by our expert application engineers. In this way, individual timing needs are met exactly . . . without incurring the cost of custom timers.

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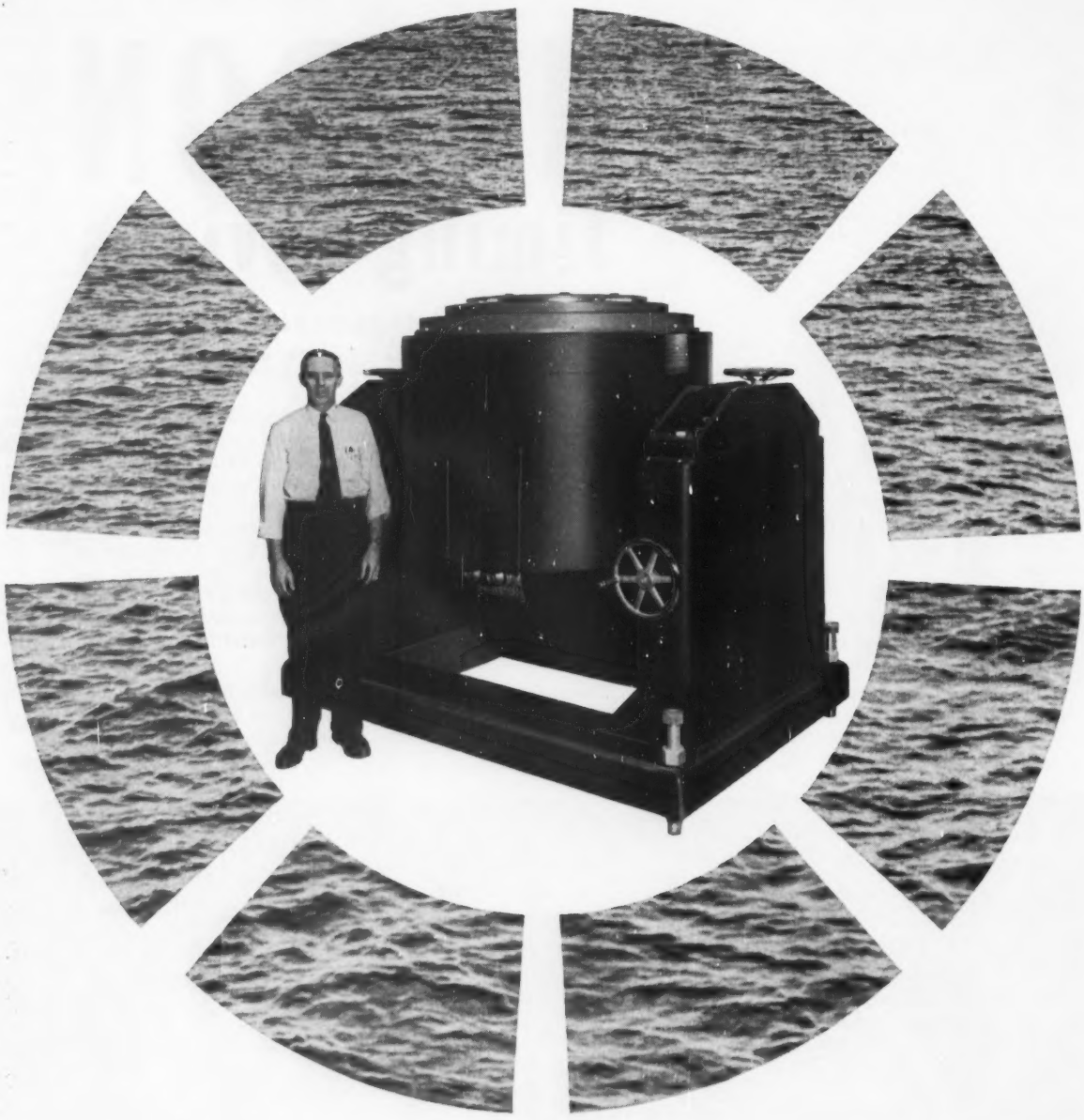

LING'S LIQUID-COOLED SHAKERS DISSIPATE HEAT FAST WITH WATER

Improved system efficiency goes with the improved design of Ling's new series of liquid-cooled shakers. For instance, Model 249 shown above not only offers an impressive 28,000 pound force rating, but a number of other advantages. The new closed-loop cooling system, employing clean raw or distilled water, dissipates heat so efficiently that less is dumped on the testing site. The series also features a new web-design armature of lightweight aluminum. Force is transmitted to the table with maximum rigidity. Finally, special construction details make these liquid-cooled shakers adaptable for environmental chamber testing without special accessories. Tests can be conducted from −100°F to 300°F at any altitude. Field and armature coils are designed to help eliminate corona at altitudes; special thermal barriers can be supplied which control heat flow from the shaker to the chamber. This built-in adaptability and high efficiency grow from Ling research; For details on the liquid-cooled shaker series, write Dept. MD-2at either address below.

LING ELECTRONICS

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Circle 419 on Page 19

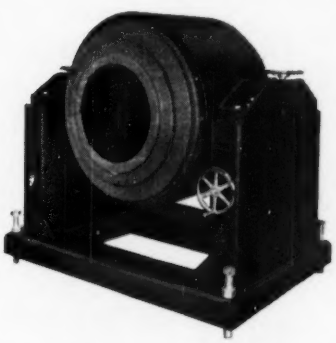
LING ELECTRONICS

The shaker at the left is just one of many design improvements to grow out of Ling's continued research and development program. Its high 28,000 pound force rating—one of the highest force ratings available—is another result of Ling's constant search for better equipment and better methods of vibration testing.

In addition to the special advantages offered by the efficient liquid-cooling system, this new series offers other important features which it has in common with the air-cooled shaker series.

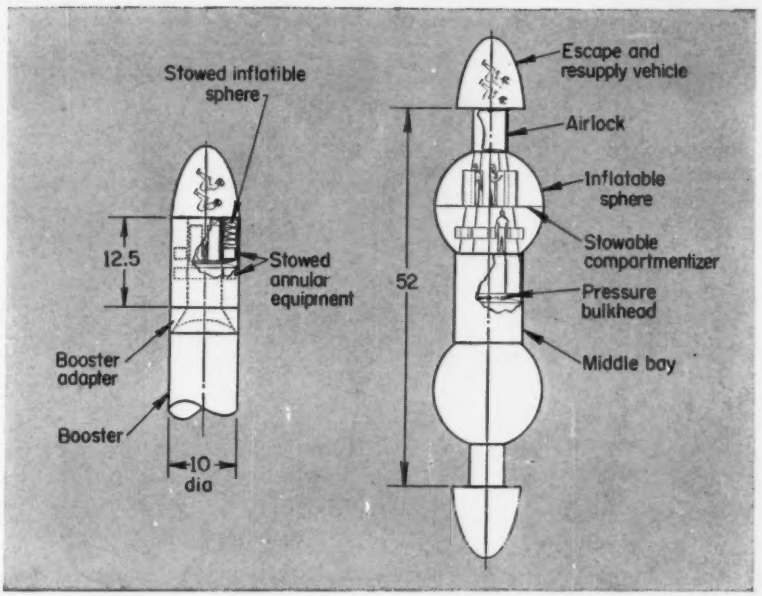
Ling's dual magnetic field structure provides a low stray field and improved force-current linearity. Ling shakers are engineered to operate continuously at maximum force on low input, feature simplified compensation over wide bandwidths.

Check the ratings on the entire liquid-cooled series. The performance of the series is just one more proof that whatever your needs in high power electronics – vibration testing, acoustics or sonar—you can rely on Ling for the most advanced design and practical engineering.



LING'S LIQUID-COOLED SHAKERS cover this useful range of force ratings:
Model 245—2,000 lb. force rating
Model A246—7,500 lb. force rating
Model 275—10,000 lb. force rating
Model 249—28,000 lb. force rating

LING
ELECTRONICS
HIGH-POWER ELECTRONICS FOR VIBRATION TESTING • ACOUSTICS • SONAR



Folding Space Station Blows Up Like a Balloon

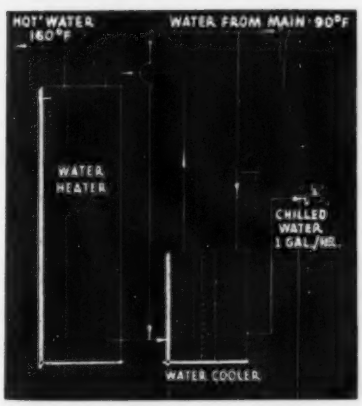
The zero pressure of outer space is put to good use by an inflatable satellite proposed by two engineers from Martin Co., Baltimore, Md. They envision a cylindrical launch vehicle that will contain two wire-reinforced elastomer spheres folded up inside. Once the vehicle is in orbit, liquefied gas would be released to inflate the spheres into space cabins connected by a rigid central cannister. Since the volume is small during launching, a significant saving in weight of the booster structure is achieved. But the proponents of the scheme point out that there are a number of unsolved problems: The uncertain behavior of elastomers under meteoric attack, the complex procedure for inflating skin-containing equipment, and the danger of lost stability should the structure deflate.

Thermoelectricity May Dismember the Icebox

CLEVELAND—Instead of one large refrigerator, built-in thermoelectric "cold drawers" may soon be strategically spotted around the kitchen. This is the prediction of W. D. Fowler, manager, Government Contracts Dept., Whirlpool Corp., St. Joseph, Mich. He told delegates at a recent American Gas Association convention that the meat drawer (refrigerator) could be next to the oven, the vegetable bin next to the sink, and so on. Decentralization would save steps and also simplify the problem of providing optimum conditions for each type of food.

Efficiencies of thermoelectric systems are still too low for most applications—including both refrigeration and power-generation units. But small-volume thermoelectric coolers are, in general, superior to their mechanical counterparts. Me-

(*Please turn to Page 40*)



One thermoelectric cooling idea that interests Whirlpool is a combination water heater-cooler. Tap water would be cooled by the cold junction, warmed by the hot junction. Cooled water would be ample for a family-size drinking-water supply; warmed water would be further heated in a standard water heater.

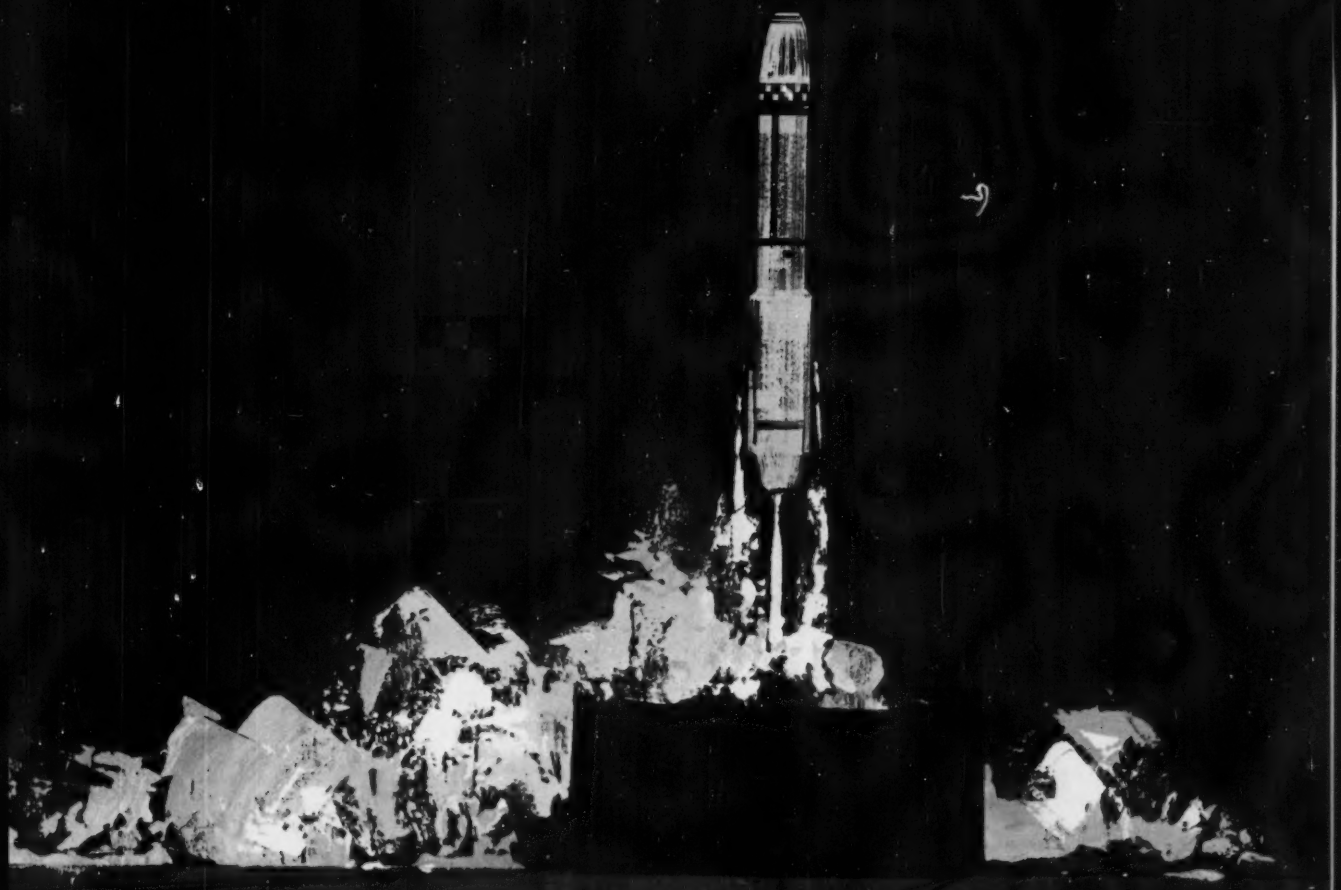
Circle 420 on Page 19→

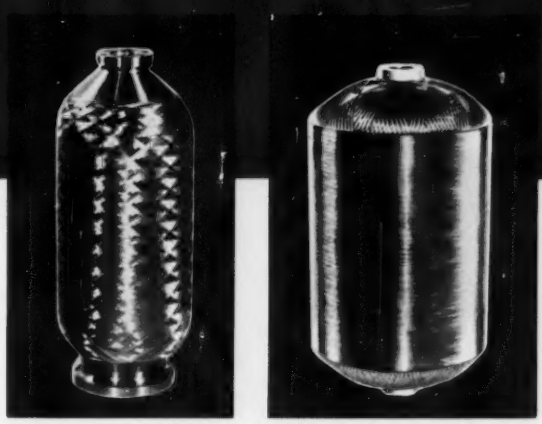
NS SPECIAL WIRE (575,000 psi) WRAPS

In the development of solid-fuel rocket cases, a leading manufacturer fabricated and experimented with welded steel and glass fibers, as well as many steel wire specimens, to find a fuel case material with the most favorable strength-to-weight ratio for fuel case applications.

EARLY DEVELOPMENT STAGES—At the outset of their testing program, the rocket manufacturer asked National-Standard to develop .004″ wire with 575,000 psi, the ultimate tensile strength required of steel wire to provide the strength-to-weight ratio needed. The wire was to be made into tapes of uniformly-stressed wires, coated with epoxy resin to separate the wires, and wound over collapsible mandrels to form the fuel case.

NATIONAL-STANDARD ENGINEERS produced .004″ high-carbon steel wire that met every specification, after intensive testing with many types of wire and finishes. Special wire developed by NS met rigid size tolerances, residual twist and controlled cast requirements.





WIRE-WRAPPED ROCKET CASES are wound over collapsible mandrels using a number of strands of very high strength, small diameter wire formed into tapes.

ROCKET FUEL CASES

The end result of NS—customer cooperation was the ability to produce wire-wrapped rocket cases with very high hoop stress and lower cost than those being produced by other methods. And the fuel case manufacturer is able to provide maximum case-to-case reliability.

EXPERIENCED ENGINEERING HELP of this kind is available to you from National-Standard to meet special or unique high-quality wire applications. Write for additional information to National-Standard Company, Niles, Michigan.

NS
NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

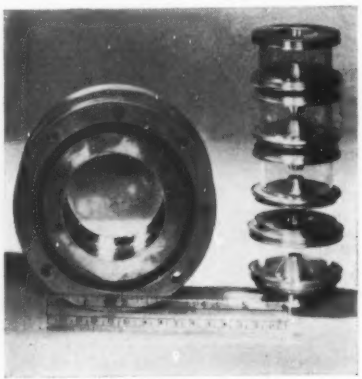
(Continued from Page 37)

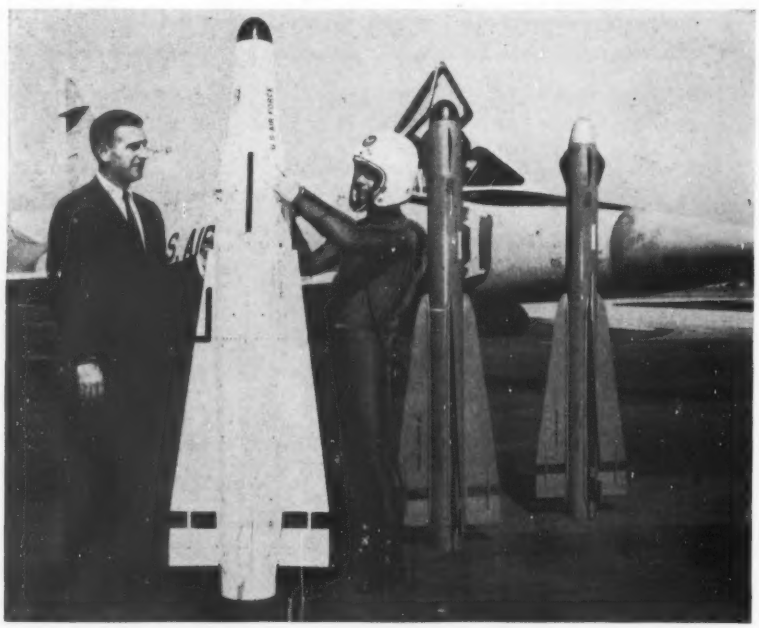
chanical systems designed to refrigerate appliances smaller than a certain minimum must all be the same size, and their efficiencies fall off as the space to be cooled becomes smaller. Thermoelectric systems, which cool a small volume as efficiently as a large one, come into their own in the small-size region.

Household refrigerators will require better and cheaper thermoelectric materials before they become marketable, says Fowler. Successful thermoelectric refrigerators, water coolers, super-sensitive temperature controllers, dehumidifiers, room air conditioners, and other appliances have been demonstrated, but they've been small—largest refrigerator designed to date has an 8 cu ft capacity. With improved thermoelectric materials, many new appliances will become practical.

Quartz-Metal Seal Perfected

A few thousand Angstroms of metal is used to coat quartz at temperatures below 1000-C. This low-temperature application prevents recrystallization of the metal, and is the secret of success in a new quartz-to-metal sealing technique developed by Eitel-McCullough Inc., San Carlos, Calif. The thin metal coating is then covered with another soft sealing metal, which will neither bond nor alloy with the original coat. The combination of metals used gives the seal great thermal stability and freedom from internal stresses.





Nuclear Punch for a Lightweight Fighter

Head of the line of mixed missiles that are carried by the Air Force's F-102 is the GAR-11 Nuclear Falcon. The first air-to-air missile with nuclear capability, it is designed for use in head-on attacks on supersonic bombers. Hughes Aircraft Co. developed the weapon with a radar guidance system which can launch it without the pilot seeing the target, and guide it to ensure a "kill." Described as small, considering its capabilities, the Falcon is 7 ft long, weighs just 200 lb.

certain.

MAJOR MERGER IN SWITCH INDUSTRY

Controls Company of America Merges Hetherington Div. With Electrosnap Corp. to form New Control Switch Division.

One of the precision switch industry's most complete product lines has come into existence with the announcement by Louis Putze, President of Controls Company of America, Schiller Park, Ill., that its subsidiary Hetherington, Inc., has been merged with Electrosnap Corporation, Chicago. The Electrosnap organization was recently merged with Controls Company of America

"This merger is important to switch users", Mr Putze stated

WHAT'S IN IT FOR YOU?

You may now select from the industry's most versatile and complete line of precision snap-action switches, indicator lights, push-button switches, toggle switches, Switchlites, and environment-free limit switches. You can now make broader product groupings for greater quantity discounts. With this new single source, you will now deal with just one sales engineer for all your switch needs.

Three plant locations—Folcroft, Pa., Chicago, Ill., and El Segundo, Calif.—will provide regional engineering and manufacturing facilities to speed delivery and service.

Local sales offices with factory-trained personnel have been set up to provide on-the-spot application engineering in all major markets. An expanded nation-wide distributor organization will assure you of immediate delivery from local sources.

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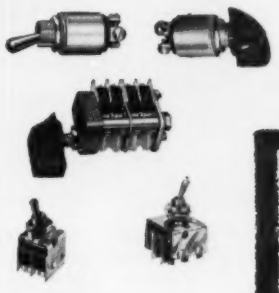
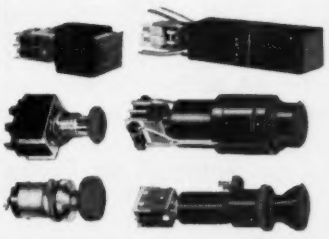
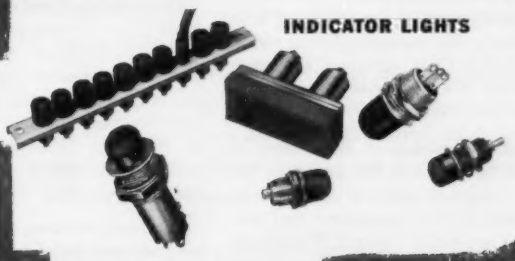


PUSH-BUTTONS

LIGHTED PUSH-BUTTONS



INDICATOR LIGHTS



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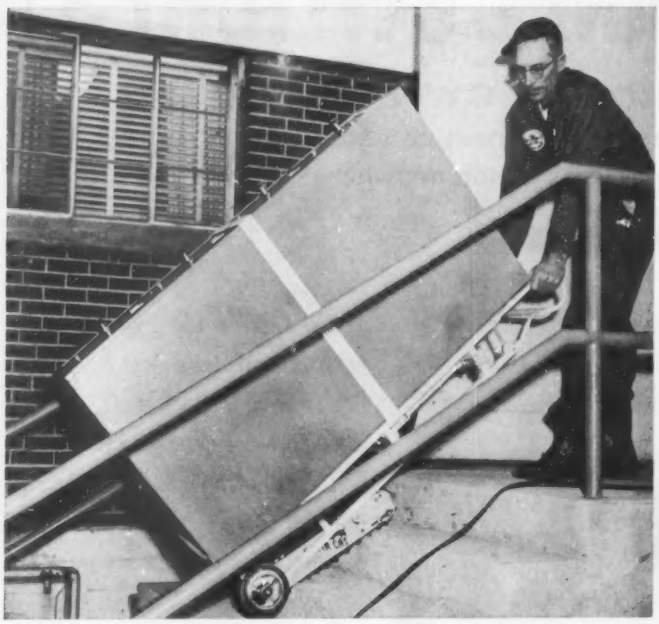
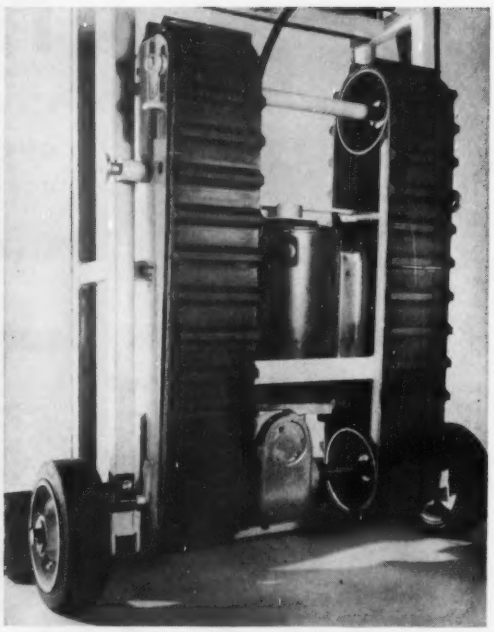
TOGGLE & ROTARY SWITCHES	PUSH-BUTTON SWITCHES	INDICATOR LIGHTS	LIGHTED PUSH-BUTTONS

Stair-Climbing Hand Truck





A track-laying vehicle moves a heavy cabinet up or down stairs with ease. Rubber tracks, powered by an electric motor, propel the truck on the stairs at a rate of 18 ft per min. carrying a maximum load of 500-lb. Power is provided from a standard 115 volt electrical outlet. In the event of a power failure, or when the 40-ft cord pulls its plug out, automatic brakes lock the tracks. Conventional wheels (unpowered) are located so that, in normal pushing position on level ground, they alone are in contact with the ground. The designers, New Design and Development Corp., Lima, Ohio, point out that an unusual feature is the ratchet strap provided to fasten the load in place easily and firmly.

Metals Matters

Shinier than chrome, high purity aluminum parts can now be produced by die casting. In a new process, Lurium alloys—99.99 per cent pure aluminum—produce brilliant, homogeneous, high-finish castings which can be dyed any color after anodizing. Corrosion resistance makes the castings suitable for marine applications. Nelmor Mfg. Co., Euclid, Ohio, developed the process, with the assistance of Fromson Orban Co., New York.

Bright aluminum in sheet form is offered by Reynolds Metals Co. as the most corrosion-resistant alloy ever available to the automotive and appliance industries. Alloy 5657 is a high purity, non-heat treatable metal produced in both flat sheet and coil form.

Coating carbon directly on steel forms an electron tube anode material. Early tests indicate that the coated material has an emissivity comparable to gas carbonized nickel-clad steel, with one-half to one-third the gas content; samples are being evaluated by tube manufacturers in actual applications. The coating process—suitable for virtually any metal—was developed by the General Plate Products group of Texas Instruments Inc., Metals & Controls Div.

Titanium powdered metal parts, produced by a low-cost process developed by the Clevite Corp., Cleveland, compare in corrosion resistance and strength to wrought parts. Commercially pure titanium or alloys can be fabricated into parts with cross sections ranging from a fraction of an inch to more than 35 sq in.

Corrosion resistance of zirconium and possible commercial uses of the metal will be discussed in a series of seminars sponsored by Carborundum Metals Co., a division of the Carborundum Co. Following the procedure of the first seminar, held May 20 at New York University, the one-day meetings will consist of talks by prominent metallurgists and researchers, followed by workshop sessions.

Meetings and Shows

June 5-9—

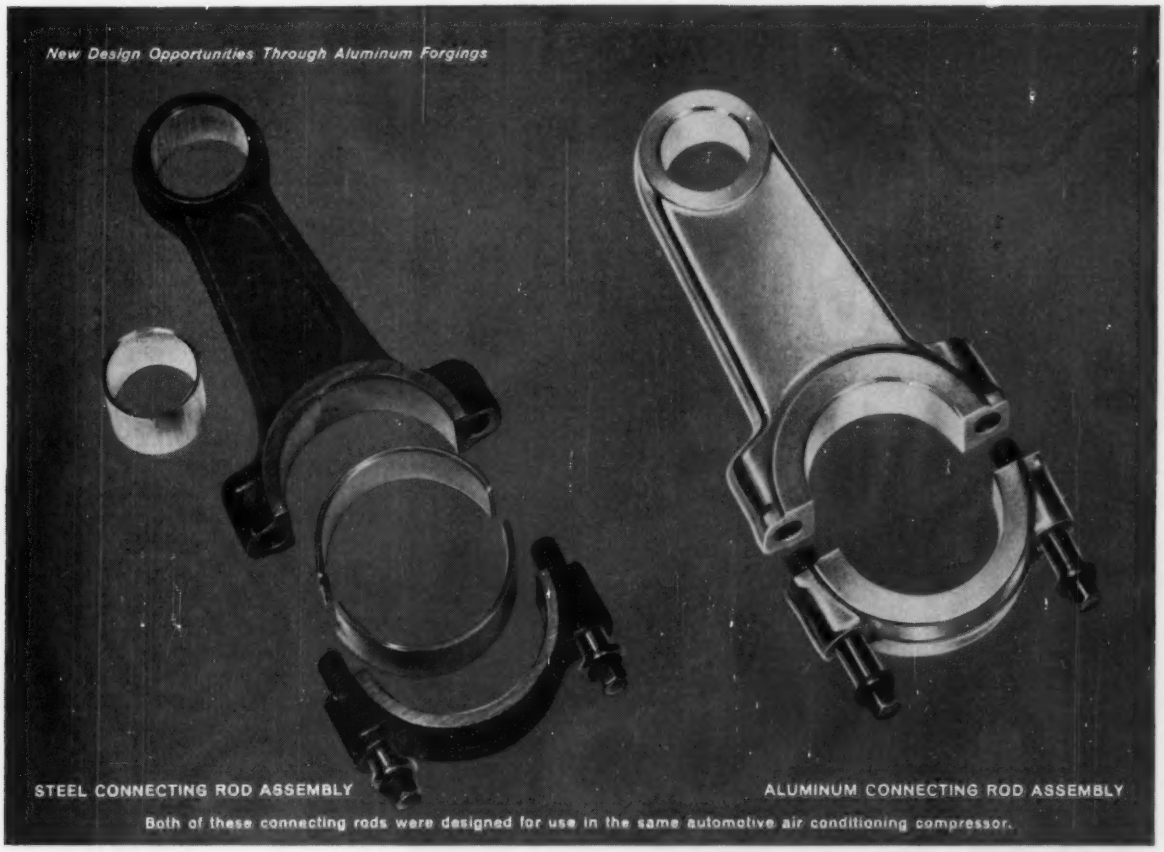
American Society of Mechanical Engineers. Summer Annual Meeting and Aviation Conference to be held at the Statler Hilton Hotel, Dallas. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

June 5-9—

Society of the Plastics Industry Inc. Ninth National Plastics Exposition to be held in the Coliseum, New York. Additional information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

June 5-10—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information can


New Design Opportunities Through Aluminum Forgings
STEEL CONNECTING ROD ASSEMBLY
ALUMINUM CONNECTING ROD ASSEMBLY

Both of these connecting rods were designed for use in the same automotive air conditioning compressor.

WHICH CONNECTING ROD COSTS LESS?

One glance tells you it's the aluminum connecting rod at the right. Two pieces are easier and less expensive to fabricate than five.

By designing this connecting rod as a Kaiser Aluminum forging, Lennox Tool & Machine Builders of Lima, Ohio, cut costs for their customer, Airtemp Division, Chrysler Corporation.

The steel connecting rod formerly used required five different pieces, including three bronze inserts for wrist pin and crankshaft bearings, plus two connecting rod bolts. Plenty of precision machining was also required.

The new aluminum connecting rod consists of only two pieces, plus the two connecting rod bolts. For this part, the forging itself was bored to provide a hard mirror-finish surface for wrist pin and crankshaft bearings, thus eliminating the three bronze inserts.

Strength? The aluminum forging meets every strength and dimensional stability requirement specified for the compressor application. In fact, the life expectancy of forged aluminum rods and steel rods with bronze insert is virtually the same!

This is another example of how strong, lightweight Kaiser Aluminum forgings can simplify design and cut material, machining and assembly costs. To find out how Kaiser Aluminum forgings can save you money, mail the coupon now!

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COHRlastic R-10470 meets: *AMS 3195; AMS 3196; Boeing BMS 1-23; Martin–MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.*

AVAILABLE FROM STOCK: in 12″ x 12″ sheets and 24″ x 24″ sheets — $\frac{1}{16}$″ through ½″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ can be made to order. COHRlastic R-10470 is sold nationally through distributors.

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June 6-7—

Malleable Founders Society. Annual Meeting to be held at the Elbow Beach Surf Club, Hamilton, Bermuda. Further information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

June 6-8—

American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information is available from AGMA headquarters, 1 Thomas Circle, N.W., Washington 5, D. C.

June 8-11—

National Society of Professional Engineers. Annual Meeting to be held at the Statler Hotel, Boston. Additional information can be obtained from NSPE headquarters, 2029 K St., N.W., Washington 6, D. C.

June 9-12—

Society of Women Engineers. Tenth Annual Convention to be held at the Benjamin Franklin Hotel, Seattle. Further information can be obtained from Mrs. J. A. Troxell, 3613 E. 43rd St., Seattle 5, Wash.

June 12-15—

American Nuclear Society. Sixth Annual Meeting to be held at the Palmer House, Chicago. Additional information is available from society headquarters, 86 E. Randolph St., Chicago 1, Ill.

June 12-16—

American Society of Agricultural Engineers. Annual Meeting to be held at Ohio State University. Additional information is available from society headquarters, 420 Main St., St. Joseph, Mich.

June 13-15—

American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Sixty-seventh Annual Meeting to be held at the Vancouver Hotel, Vancouver, B. C. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

June 13-17—

International Powder Metallurgy Conference to be held at the Biltmore Hotel, New York. Sponsors are Metal Powder Industries Federation and Powder Metallurgy Committee, Institute of Metals Div., the Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers. Additional information can be obtained from MPIF headquarters, 60 E. 42nd St., New York 17, N. Y.

June 19-24—

American Institute of Electrical Engineers. Summer General Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

June 20-22—

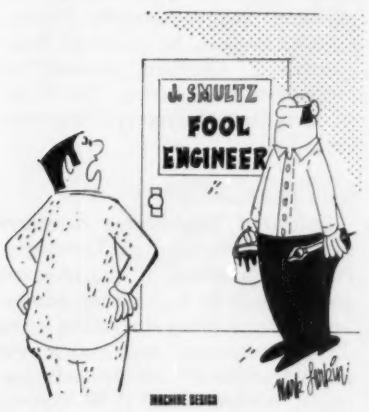
American Society of Mechanical Engineers. Applied Mechanics Conference to be held at Pennsylvania State University, University Park, Pa. Additional information can be obained from ASME, 29 W. 39th St., New York 18, N. Y.

June 20-24—

American Society for Engineering Education. 68th Annual Convention to be held at Purdue University, Lafayette, Ind. Further information is available from W. Leighton Collins, University of Illinois, Urbana, Ill.

June 26-July 1—

American Society for Testing Ma-



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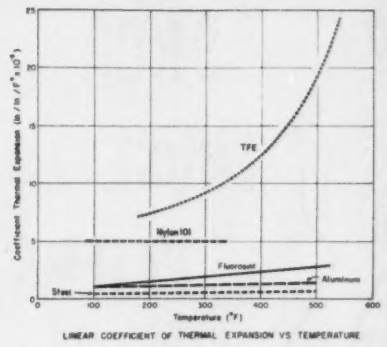
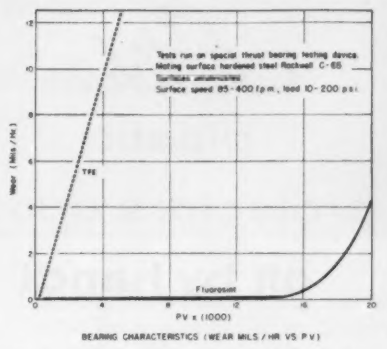


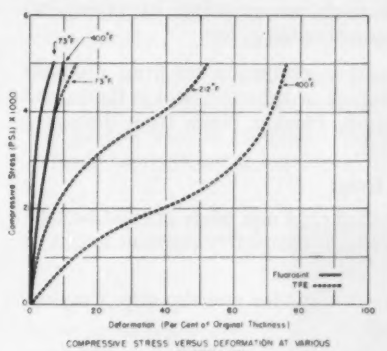
LINEAR COEFFICIENT OF THERMAL EXPANSION VS TEMPERATURE

(1) in dimensional stability FLUOROSINT's coefficient of thermal expansion is as low as aluminum.


Tests run on special thrust bearing testing device.
Mating surface hardened steel Rockwell C-65
Surfaces unlubricated
Surface speed 85-400 f.p.m., load 10-200 p.s.i.
Wear (Mils / Hr.)
TFE
Fluorosint
PV x (1000)

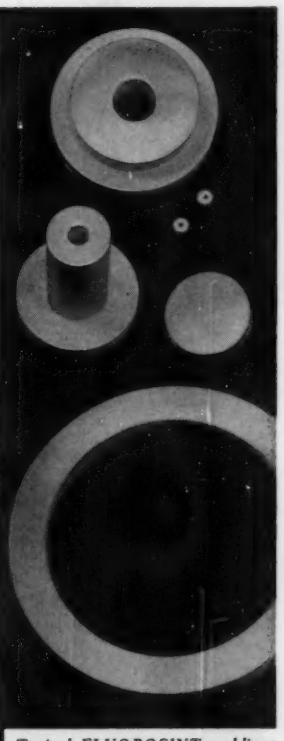
BEARING CHARACTERISTICS (WEAR MILS / HR VS P.V.)

(2) in bearing characteristics FLUOROSINT operates at higher loads and speeds, shows far more wear life.



COMPRESSIVE STRESS VERSUS DEFORMATION AT VARIOUS TEMPERATURES

(3) in resistance to cold flow and creep FLUOROSINT parts are more rigid, resist deformation at high temperatures.



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POLYPENCO

Circle 424 on Page 19

OK LOUIE, DROP THOSE PLIERS!

S. Silbhite plastic protectors come off by hand!

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Economy Line... elastic vinyl for non-slip grip. Easy-on, easy off, yet a stay-put fit.

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terials. Annual Meeting and Exhibit to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 27-30—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Further information is available from IAS, 2 E. 64th St., New York 21, N. Y.

Aug. 8-12—

American Institute of Electrical Engineers. Pacific General Meeting to be held at the El Cortes Hotel, San Diego, Calif. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

June 6-17—

Course on radioisotope theory, applications, and safe handling to be held at the University of California at Berkeley, with the co-operation of the U. S. Atomic Energy Commission. Further information is available from the Engineering and Sciences Extension, University of California, 2451 Bancroft Way, Berkeley 4, Calif.

June 12-17—

Design Engineering Seminar to be held at Pennsylvania State University. Lecture and workshop sessions are aimed at developing and applying creative thought. Further information can be obtained from Maurice S. Gjesdahl, professor of Mechanical Engineering, The Pennsylvania State University, University Park, Pa.

June 14-17—

Industrial Engineering Seminars to be held at Cornell University. Participants enroll in one of seven groups (such as engineering administration or systems simulation using digital computers) and also attend general sessions. Further information is available from J. W. Gavett, Seminars Co-ordinator, Dept. of Industrial and Engineering Adminis-

tration, Upson Hall, Cornell University, Ithaca, N. Y.

July 11-15—

Institute in Technical and Industrial Communications to be held at Colorado State University. Purpose is to provide counseling and basic and advanced instruction in technical writing and related communications. Additional information is available from the director of the Institute, Colorado State University, Fort Collins, Colo.

July 18-22—

Survey course on radioisotope principles and techniques, designed to increase management understanding of basic concepts, to be held at the University of California at Berkeley, with the co-operation of the U. S. Atomic Energy Commission. Further information can be obtained from the Engineering and Sciences Extension, University of California, 2451 Bancroft Way, Berkeley 4, Calif.

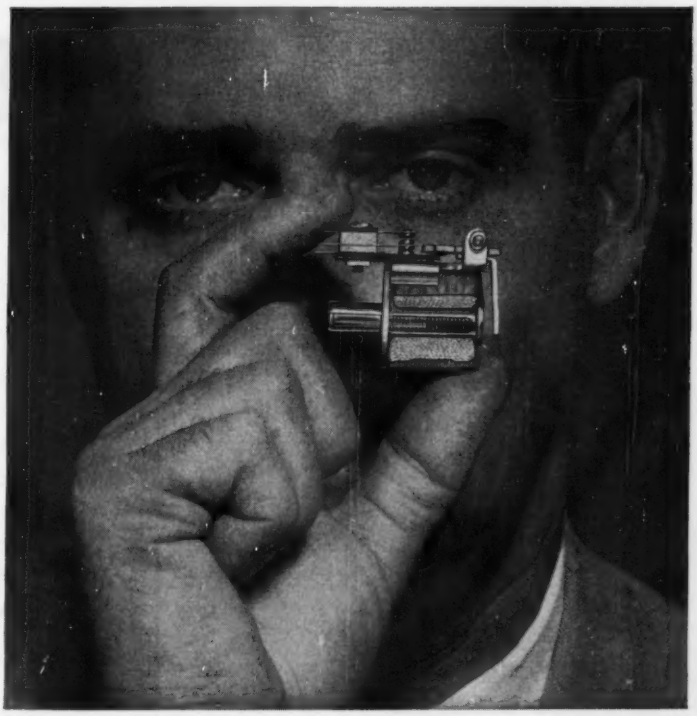
July 24-29—

Research and Development Management Development Seminar, to help middle management representatives develop skills in administration and human relations, to be held at Pennsylvania State University. Additional information can be obtained from the Continuing Education Conference Center, The Pennsylvania State University, University Park, Pa.

"He's versatile, all right—he can louse up any job you give him."

COMPACT, 3-OUNCE TIME DELAY RELAY

with silicone-controlled delay from 1/4 to 120 seconds



Worth a closer look . . . the Heinemann Type A Silic-O-Netic Relay. Despite its small overall size, the relay offers many big performance features.

For example, double-pole, double-throw switching . . . at fast snap-action contact speed.

The relay is a load carrier in itself: it may be energized continuously . . . does not require auxiliary lock-in circuits.

And it has a hermetically sealed time element that is forever free from the effects of aging or fatigue. The Type A Relay has proven itself in countless applications; it will give you reliable service over a long, long operational life.

For full details, refer to Bulletin T-5002. A copy will be sent on request.

BRIEF SPECS

Time Delays: from 1/4 to 120 seconds

Overall Dimensions: 2-1/16" x 2" x 1-9/16"

Contact Capacity: 3 amps at 120V AC, 1.5 amps at 240V AC (non-inductive load), 1 amp at 50V DC, 0.5 amp at 125V DC.

HEINEMANN
ELECTRIC COMPANY
172 Plum St., Trenton 2, N. J.

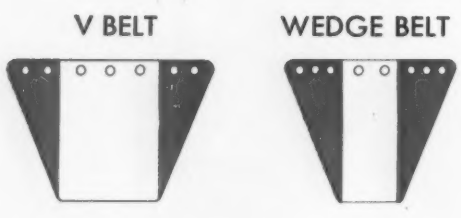
S.A. 1078

Circle 426 on Page 19

An important Worthington message about

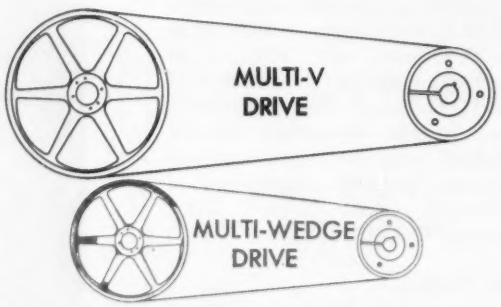
THE COMING CHANGEOVER FROM

Recently you may have seen a number of announcements promising "super" V-belt drives that are considerably smaller and less expensive. What these manufacturers are talking about, of course, is the new Wedge belt which will soon replace conventional V belts for new belt



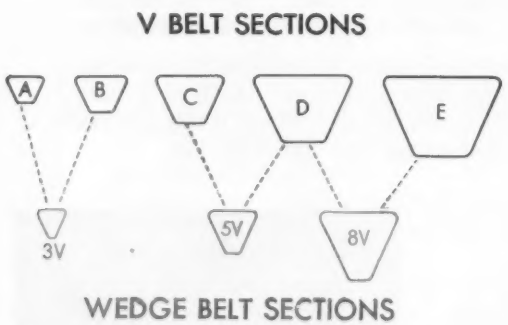
Q. What is a Wedge belt?

A. The cord layer near the top of a V belt carries the load. This layer, however, is only efficient in the portion supported by side walls (red areas). Because it is more of a pie shape, a Wedge belt increases the overall efficiency of a V belt. The Goodyear Tire and Rubber Company (manufacturer of Worthington-Goodyear V belts) was the first to offer a Wedge belt (in 1948). This fine product, however, was sold primarily for automotive applications.



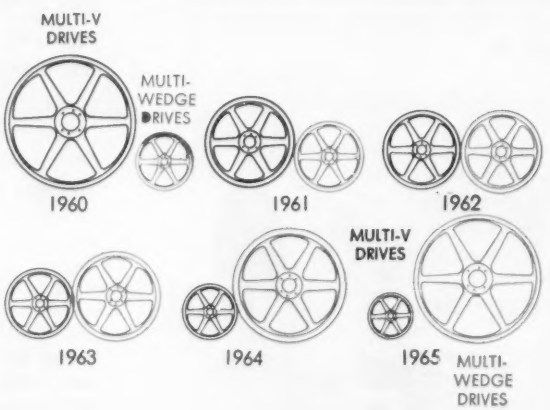
Q. What are the advantages of Wedge belts?

A. Smaller size, lower cost. Because the new Wedge belts are more efficient, you need fewer belts and smaller sheaves to carry the same horsepower load. Sheave diameters can be reduced 30 to 50%. Center distances can be cut 20%. And initial cost can be as much as 20% less.



Q. What belt sizes will be available?

A. Since the smaller Wedge belt does more work than the other V belt, it has been possible to reduce the number of sizes without loss of flexibility. The new Wedge belts will be available in three standard sections, 3V, 5V and 8V. The new nomenclature simplifies identification. The 3V belt is three eighths of an inch in width (measured at the top); the 5V belt is five eighths; the 8V belt, eight eighths, or one inch. Stock 3V and 5V sheaves will cover horsepower ranges up through 200 hp. Made to order 8V sheaves will be used for 200 to 2,000 hp. requirements.



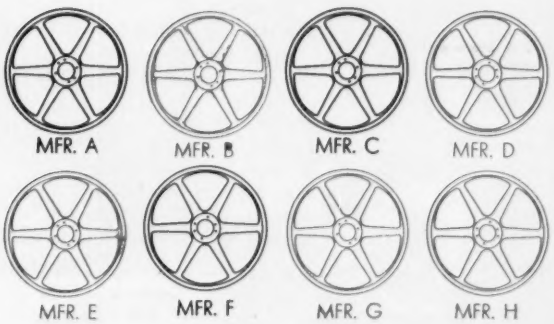
Q. Will multi-V drives continue to be available?

A. Worthington has no intention forcing any customer to switch to the new Multi-Wedge drive. The choice is up to you. We will continue to manufacture and stock both drives as long as there is a demand for both. We expect that many customers will need replacement belts and sheaves for Multi-V drives for many years. The chart above indicates how we expect the market to be divided in the years ahead.

MULTI-V TO MULTI-WEDGE DRIVE

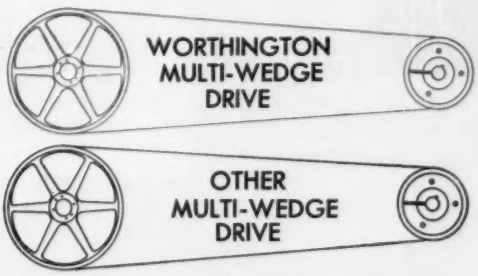
drive applications. On these pages Worthington—maker of the QD (Quick Detachable) sheave, the industry's largest seller—explains the significance of the coming change-over. If you would like more information please write to Worthington Corp., Section 79-25, Oil City, Pa.

WORTHINGTON



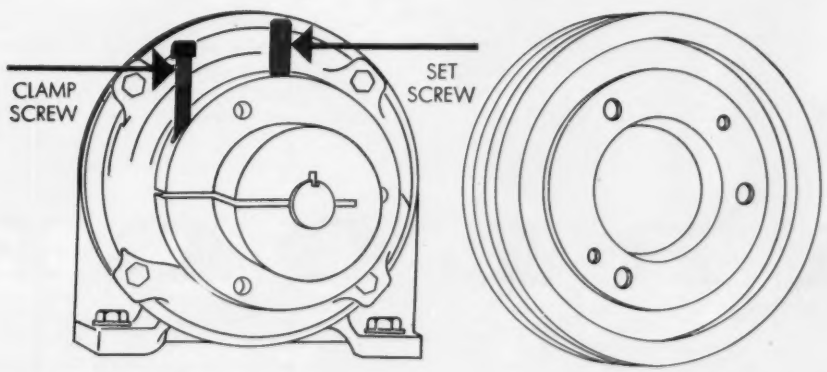
Q. Will all drive manufacturers make the changeover?

A. All indications are that the majority of Multi-V drive manufacturers are going to switch to the new Wedge belts. Of the eight leading builders, five (including Worthington) now also offer Multi-Wedge drives.



Q. Will different brands be interchangeable?

A. So far all Multi-Wedge drives introduced are being offered in the same belt and sheave sizes. Since Worthington and its QD licensees enjoy the largest share of the market, you can be doubly sure of having a dependable source of supply if you buy your Multi-Wedge drives from Worthington. All stock QD sheaves are being built to standardized dimensions by all QD manufacturers and are therefore interchangeable.



Q. Are all Multi-Wedge drives alike?

A. Whether you buy a new Multi-Wedge drive or the older Multi-V drive, the major difference between brands will be the quality of the belt and the method of locking the hub to the shaft. Worthington QD (Quick Detachable) sheaves, with their two Golden Screws are preferred by plant operators because of their positive locking arrangement.

The clamp screw simplifies installation and assures permanent alignment. You can install QD sheaves one part at a time. No heavy rim and hub combination to inch delicately into place. If change in speed is required, you simply install another sheave on the hub which remains anchored to the shaft. The clamp screw is an exclusive Worthington feature.

The set screw prevents "key drift." It locks the key securely in place, avoiding the danger of the key drifting off and becoming a safety hazard. Because of the exclusive clamp screw it is possible to use a set screw without causing hub distortion that might cause eccentric runout.

Circle 427 on Page 19

ANNOUNCING A NEW CORPORATE NAME

for The Garlock Packing Company

Garlock Inc. becomes the new name for The Garlock Packing Company, Palmyra, N. Y., to reflect more accurately its broad diversification of products and markets.

Originally established to manufacture mechanical packings, Garlock now produces over 2,000 different styles of packings, gaskets, seals, molded and extruded rubber and plastic products for every major industry.

The new corporate name, Garlock Inc., more closely identifies this 73-year-old company with the growth and development of its product lines. *Today, industry goes to Garlock for such widely diversified products as:*

- Hydraulic-Pneumatic Packings
- Oil and Grease Seals
- Gasketing and Expansion Joints
- Braided Packings
- Molded and Extruded Rubber Parts
- Plastic Stock Shapes and Fabricated Parts
- Mechanical Seals for Rotating Shafts
- Metal Packings
- Leather Packings
- Electronic Components
- Dry Bearing Materials
- Fluorocarbon Tank Linings
- Missile and Rocket Components

To help you in selecting or applying these products, Garlock offers the services of over 126 thoroughly-trained sales engineers, 175 electronic component manufacturers' representatives, 180 authorized bearing distributors and 69 foreign distributors. Conveniently located warehouses and stocking points assure Garlock customers of prompt delivery.

At Garlock Inc., design and development of new or improved products and materials is an ever-present objective. To this end Garlock maintains extensive research and laboratory-test facilities. In addition, Garlock engineers and chemists are always ready to work with you in seeking solutions to tough application problems.

GARLOCK

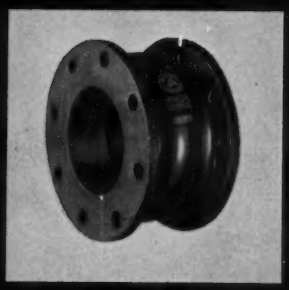
To find out more about "the new Garlock," call the nearest of our 26 sales offices, or write to Garlock Inc., Palmyra, N. Y. *To assure prompt attention,* please refer to *Garlock Inc.* on all future correspondence and orders.

Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

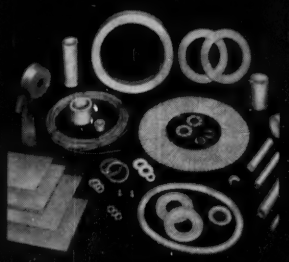
Circle 428 on Page 19

Hydraulic-Pneumatic Packings



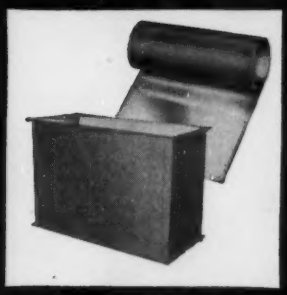
Expansion Joints

Molded and Extruded Rubber Parts

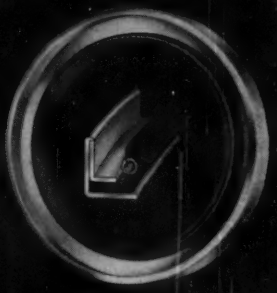


Plastic Stock Shapes and Fabricated Parts

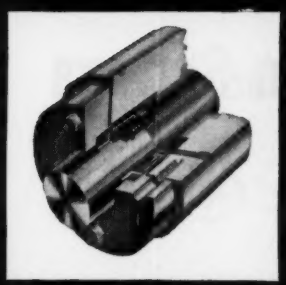
Braided Packings



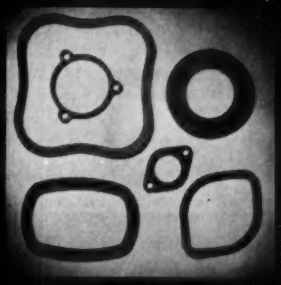
Fluorocarbon Tank Linings



Oil and Grease Seals



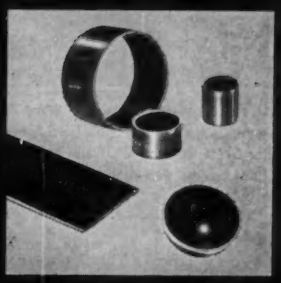
Mechanical Shaft Seals



Gasketing

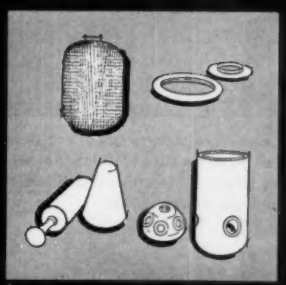
Spiral Wound Gaskets

Metal Packings

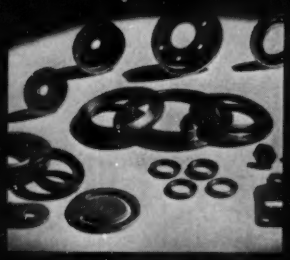


Dry Bearing Material

INC.

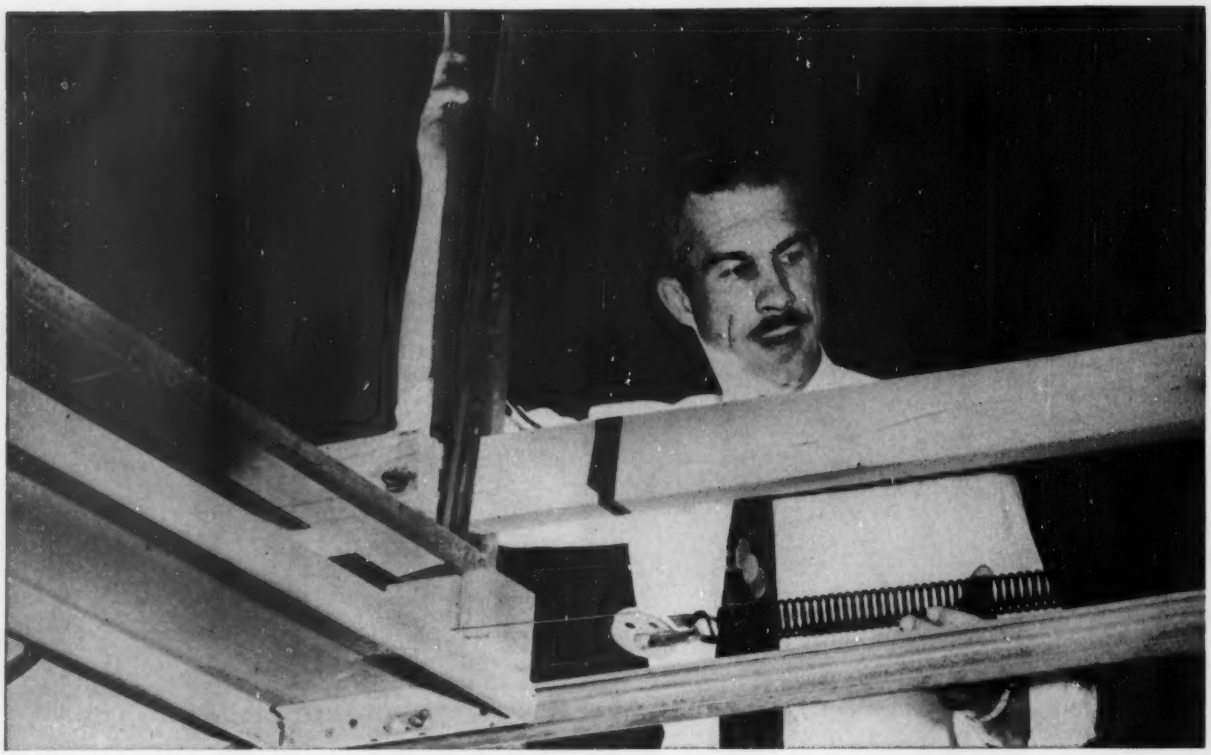


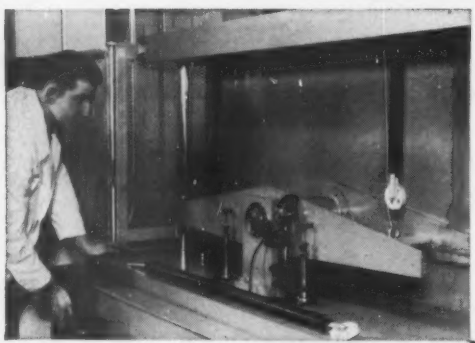
Missile and Rocket Components



Leather Packings

Electronic Components

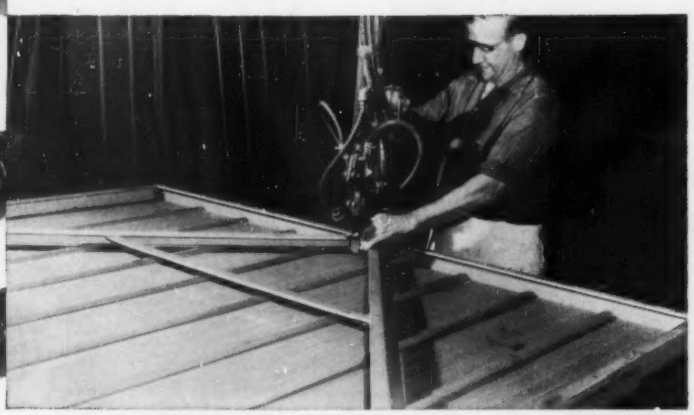




At Steel Door . . .

USS American Springs thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

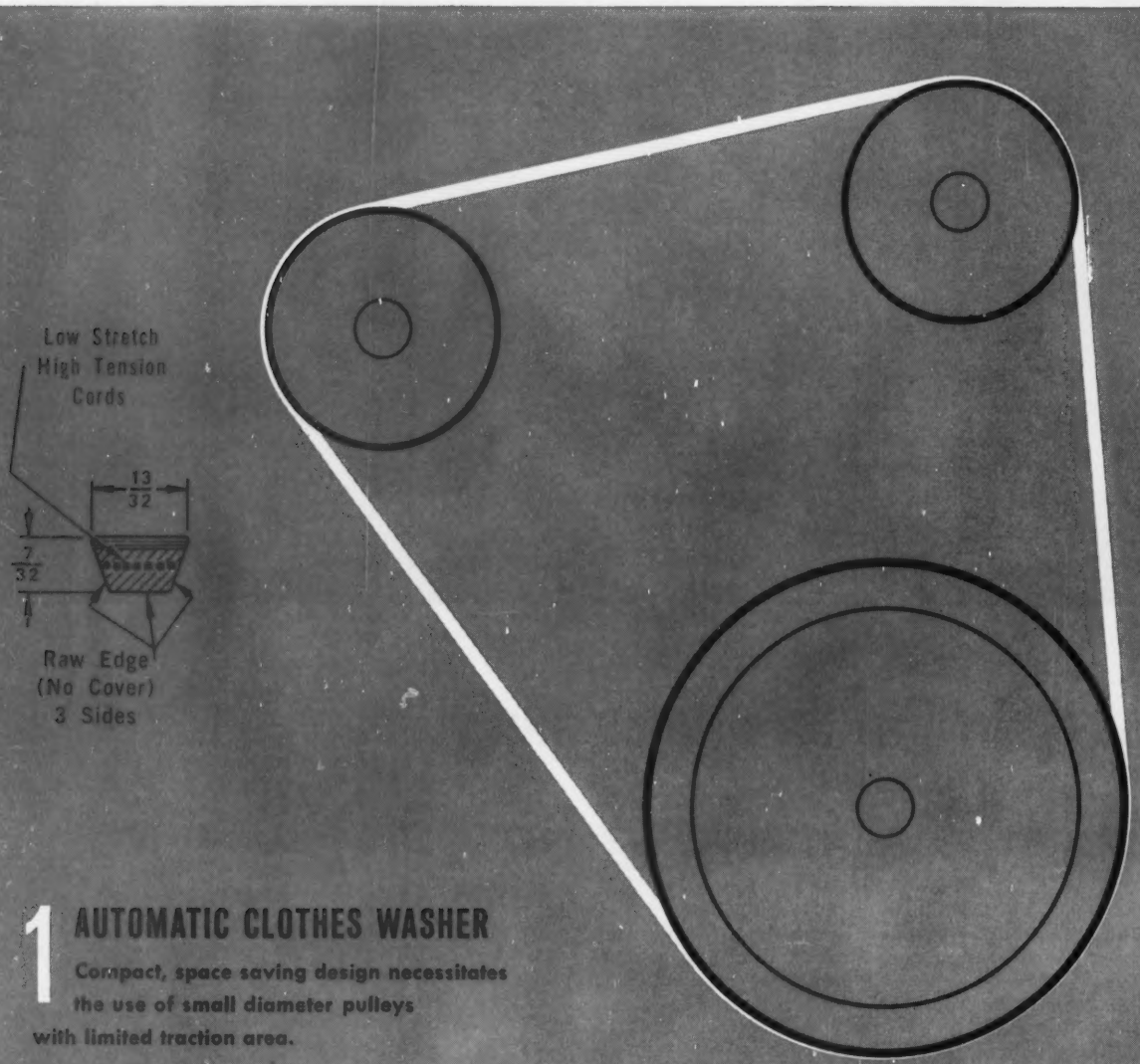
Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.* *USS and American are trademarks*

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

3 Appliances 3 Drives 3 Problems..



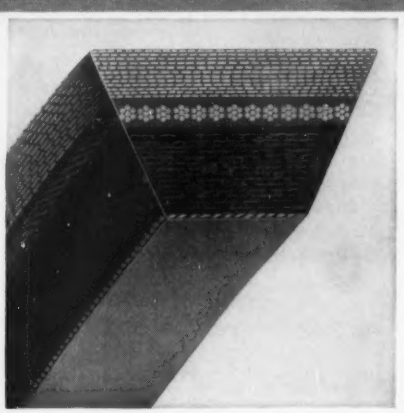
1 AUTOMATIC CLOTHES WASHER

Compact, space saving design necessitates the use of small diameter pulleys with limited traction area.

REQUIREMENT: *Transmit high loads using sub-diameter pulleys.*

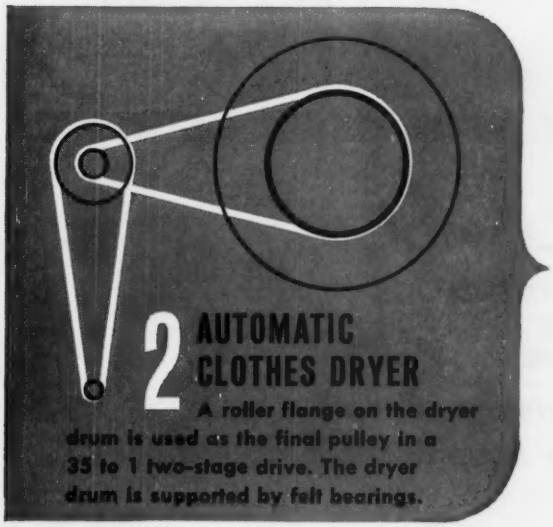
PROBLEM: The limited arc of contact caused belt slippage and premature failure when operating at high speed under heavy loads. Tension adjustment was limited and somewhat inaccessible.

SOLUTION: Dayton engineers produced a Die-Cut plate molded FHP V-Belt with a high coefficient of friction for greatest tractive effort with limited contact area. Extremely low stretch cords were used to minimize the need for tension adjustment. Redesigning around larger pulleys and heavier belts was unnecessary.



Dayton F.H.P. V-Belts are ideally suited to appliance drives. Dayton Engineers will gladly recommend a belt that is perfectly suited to your drive designs.

with ONE OUTSTANDING SOLUTION, DAYTON Molded Die-Cut V-BELTS



2 AUTOMATIC CLOTHES DRYER

A roller flange on the dryer drum is used as the final pulley in a 35 to 1 two-stage drive. The dryer drum is supported by felt bearings.

REQUIREMENT: *Transmit high loads with minimum belt tension.*

PROBLEM: Belt tension had to be minimal to prevent overloading the felt bearing. Under heavy loads standard belts slipped and dusted.

SOLUTION: Plate molded, Die-Cut Dayton FHP V-Belt was specified for the job because of its extremely high coefficient of friction, natural wedging action and low dusting characteristics. The belt performed perfectly and allowed clean, maintenance-free operation.

REQUIREMENT: *Transmit high loads at varying speeds without vibration.*

PROBLEM: Interdigitary Pulleys tended to twist belts and set up vibrations. Long periods of idleness would give the belt a "set." The belt had to carry heavy loads, flex over small pulleys and—for safet—slip under overload.

SOLUTION: A special plate molded, Die-Cut FHP V-Belt was compounded from special rubbers and fabrics which can only be used in this type of construction. A full laminated section was manufactured under exacting width and length controls. In use the belt has performed ideally . . . and has given long service life as well.

3 MULTI-PURPOSE HOME WORKSHOP TOOL

Interdigitary Pulleys provide an extraordinarily wide range of variable speeds within a limited drive space. Pitch diameter of each pulley can be varied from 1½" to 5⅜".

DAYTON'S V-BELT ENGINEERING SERVICE SERVES YOU

For help with your drive design problems Dayton Engineers are at your service to provide you with the correct V-Belt to fit all your requirements. For more information write to the Dayton Industrial Products Company (see address below) or, better yet, call EStebrook 9-5700 and arrange an appointment with one of Dayton's V-Belt Design specialists.

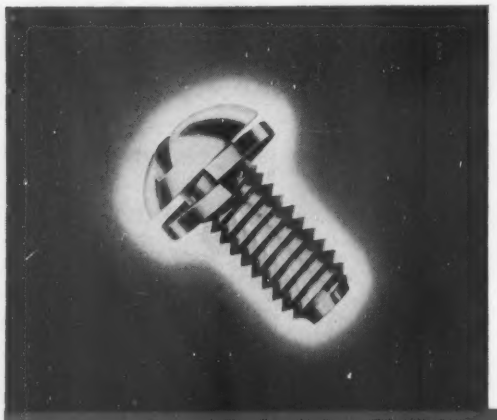
©D. R. 1960

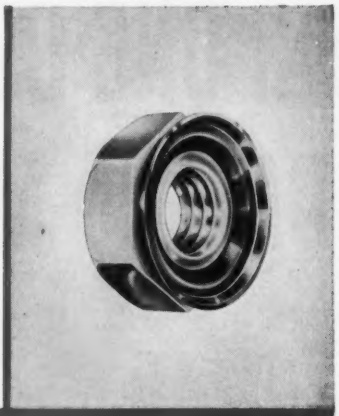
Dayton Industrial Products Co.

Division of Dayco Corporation (formerly Dayton Rubber)

2001 Janice Avenue Circle 430 on Page 19 *Melrose Park, Illinois*

Dayco

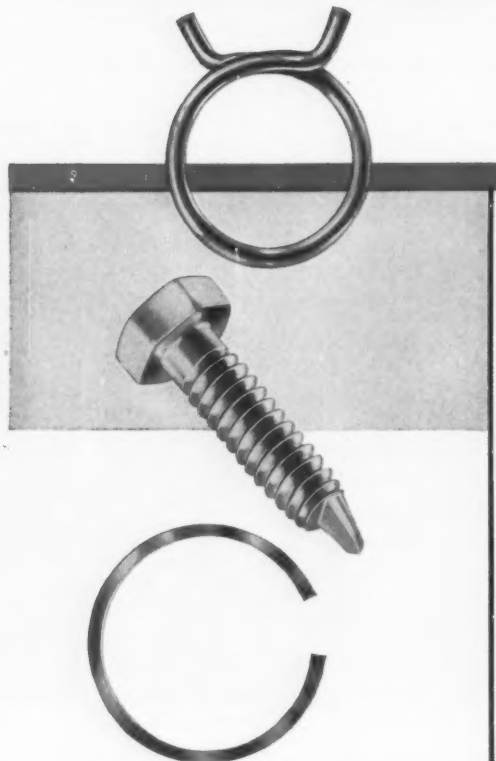




EATON-RELIANCE

FASTENERS

unseen muscles in assembled products



Because the initial cost of a fastener represents only a minor part of the total cost of "using" it in an assembly, the bulk of your fastener savings will come from these features: engineering assistance to insure use of proper fastener, ease of handling on the assembly line, stock availability and service. Metal quality, strength, vibration resistance, durability and manufacturer's reputation are also important parts of your "fastener package."

You can get all of these things by specifying Eaton-Reliance fasteners. They've been used by manufacturers of assembled products for almost half a century.

Write for our new 16 page full line catalog containing complete information.

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

Circle 431 on Page 19

OEM Guide to Electric Heaters

How to select the exact heating element to meet your product requirements

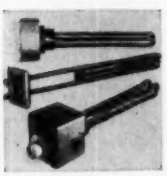
Here's condensed information from General Electric to help you get the most economical heater for your products.

CARTRIDGE HEATERS

• **Applications**—Efficient, self-contained heaters, for use singly to provide a "spot" of heat, or grouped to heat larger surfaces. Perfected for use in process machinery and for localized heating requiring close thermal control: dies, platens, molds, extrusion and injection barrels, gluepots, compound pots.

• **Features**—Durable nickel-chromium resistance wire packed in insulation and sheathed in metal tube.

• **Ratings**—30 to 2800 watts—Sheath temperatures: brass (750F); nickel-silver (1000F); chrome-steel (1200F)—Over-all lengths: 1½ in. to 2 ft.—Diameters: ⅜ in. to 1.293 in.—115v to 230v.



IMMERSION HEATERS

• **Applications**—Offer clean, economical method of heating various liquids in tanks, kettles, jackets and other containers. Suitable for immersion in water, oil, alkaline solutions, nickel, copper, chrome, plating solutions, mild sulphuric acid baths and salt baths.

• **Features**—Long life—Easily installed—Easily controlled—Sealed terminals—Excellent insulation and heat conduction.

• **Ratings**—Both through-the-side and over-the-side models available—Sheath materials: copper, nickel-silver, stainless steel, Inconel and lead—115v to 230v—Wide variety of models from 650 to 10,000 watts.

FIN TUBULAR HEATERS

• **Applications**—Especially suited to forced-convection air heating applications, such as air ducts with forced-air circulation, blower-type electric unit heaters, car heaters, recirculating ovens, industrial processes requiring heated air blasts for drying, baking, testing or pre-heating.

• **Features**—Large radiating surface per unit length—Fins sturdily attached by brazing—Quick heat transfer—Nonoxidizing rust-resistant finish—Durable construction.

• **Ratings**—Wide variety of shapes available—Sheath temperature: steel (850F)—Watts: up to 100 per linear inch.

TUBULAR HEATERS

Applications—Applicable to practically every low-temperature (1500F or lower) requirement, whether heating liquids, air, soft metals, or metal surfaces. Typical applications: ovens, ducts, platens, pipes, space heaters.

• **Features**—High-quality resistance wire, insulated in metal tubing—Heaters bent to conform to almost any shape, cast into metal, located in drilled holes, grooves, or spaced away from surfaces.

• **Ratings**—Standard ratings, 500 to 5000 watts; special ratings available—Sheath materials: steel (750F); nickel-silver (1000F); stainless and Inconel (1500F); copper (212F in water).

STRIP HEATERS

• **Applications**—Designed for direct clamping to surfaces. Typical applications: process machinery, drying ovens, matrix scorchers, warming tables, glue tables, water baths, drying cabinets, pipelines, incubators, valve and pump houses, telephone switchboards, roll heating, packaging machinery.

• **Features**—Uniform heat distribution—Corrosion-resistant sheath materials—Easy to install—Moderate cost—Uniformity.

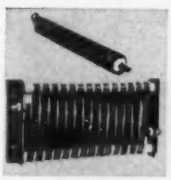
• **Ratings**—Provided with offset terminals at one end or terminals at each end—Sheath materials: Aluminized-steel (1000F); Chromized-steel (1200F).

METAL-MELTING HEATERS AND POTS

• **Applications**—Feature cast-in immersion heaters for melting lead, babbitt, tin, solder, type metal and similar metals up to 950F. Applications: dip soldering of subassemblies, railway and repair shops, electric service shops, printing plants, manufacturing plants, remelting metals.

• **Features**—Heat generated right in metal for quick heating, low radiation losses—Heater easily replaced without interrupting production—Reliable, safe, economical—Can be tied in with automatic temperature control.

• **Ratings**—Standard melting pots—Wt. 50 to 2000 lbs—Watts: 750 to 30,000.

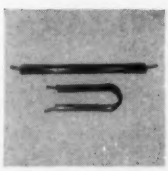


OVEN HEATERS

• **Applications**—Designed for such applications as baking, japan, foundry cores, drying, low-temperature drawing ovens, and for general air heating applications in which there is free movement of air by convection. Heaters used in recirculating type ovens for core baking, paint drying, tempering, air heating in ducts, placement inside oven.

• **Features**—Easily mounted on side walls of oven or in ducts—Wide range in heater ratings and combinations of heaters.

• **Ratings**—Temperatures: Two models available: 750F–1000F, and up to 1200F.



VANE-TYPE HEATERS

• **Applications**—Used for air and surface heating applications: baseboard heaters, pipe heating, platen heating, valve and pump heating, drying cabinets and ovens, process machinery, compound tanks.

• **Features**—Rugged tubular construction resists mechanical shock and vibration—Large, 1¾ in. wide radiating surface—Low heat density: 25 watts per linear in. of vane; 14.3 watts per sq. in. of heater surface—Can be easily formed—Convenient mounting holes.

• **Ratings**—Variety of models from 500 to 2500 watts—115 to 230 volts—Over-all lengths: 24 to 104 inches—Maximum operating temperature 750F.

GENERAL ELECTRIC

Section C723-39, General Electric Co.
Schenectady 5, N. Y.

Please send GEC-1005, "Catalog of G-E Heaters and Devices."

NAME _____

COMPANY _____

ADDRESS _____

CITY _____

STATE _____

Circle 432 on Page 19

Circle 433 on Page 19→

How General Electric's TRI 55 CLAD motor gives you MORE THAN A MOTOR . . .

ON-TIME DELIVERY OF THE EXACT MOTORS YOU NEED

Every order you place—large or small—for G-E Tri/Clad '55' motors is important to General Electric. Consequently, you can depend on getting just the motors you need, and on time.

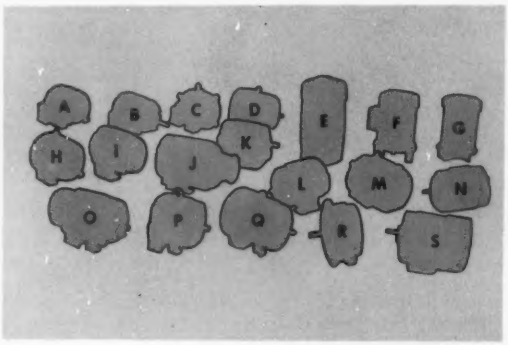
This prompt service is made possible by:

LOCAL WAREHOUSING—You can get off-the-shelf delivery of standard Tri/Clad '55' motors from a nationwide network of motor warehouses. Your choice of over 300 models from factory, local warehouse and distributor stock is as near to you as your telephone.

FLEXIBLE FACILITIES—General Electric's modern motor plants feature high-speed production lines to provide short-cycle delivery on a full line of standard and industry-specified Tri/Clad '55' motors.

Immediate availability and prompt delivery of the *exact* motors you need is General Electric's way of making your purchase truly *more* than a motor. For more information contact your local G-E Apparatus Sales Office, or write Section 840–31, General Electric Co., Schenectady 5, New York.

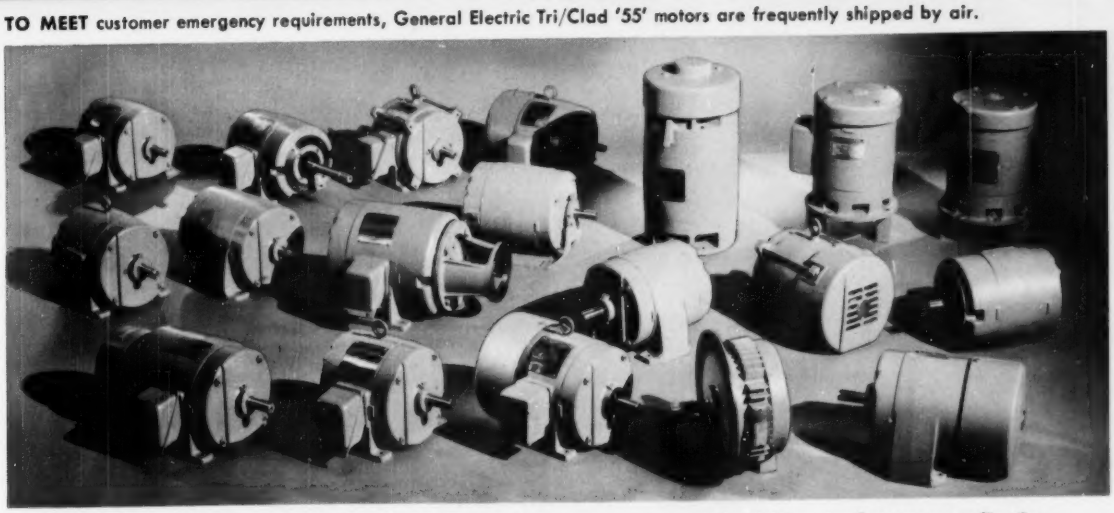
Other "More Than A Motor" benefits of G-E Tri/Clad '55' Motors: Expert Application Aid • Constant Design Innovation • Complete Line • Fast, Local Backup Service • Durable, Long-life Performance.



FULL LINE of Tri/Clad motors includes: (A) Footed dripproof, polyphase (B) C-face, close-coupled pump (C) Explosion-proof, non-vent (D) TEFC (E) Vertical, hollow-shaft (F) Vertical, solid-shaft, P-base, single-phase (G) Vertical, solid-shaft, P-base polyphase (H) Enclosed, air-over (I) Single-phase, general-purpose (J) Hydraulic pump (K) Dripproof, resilient base (L) Single-phase, farm motor (M) Explosion-proof, fan-cooled (N) C-face, round-frame (O) Brake motor (P) Enclosed non-ventilated, polyphase (Q) TEFC, severe duty (R) Thinline, enclosed (S) Fan-cooled, single-phase. All give Tri/Clad '55' motor quality.

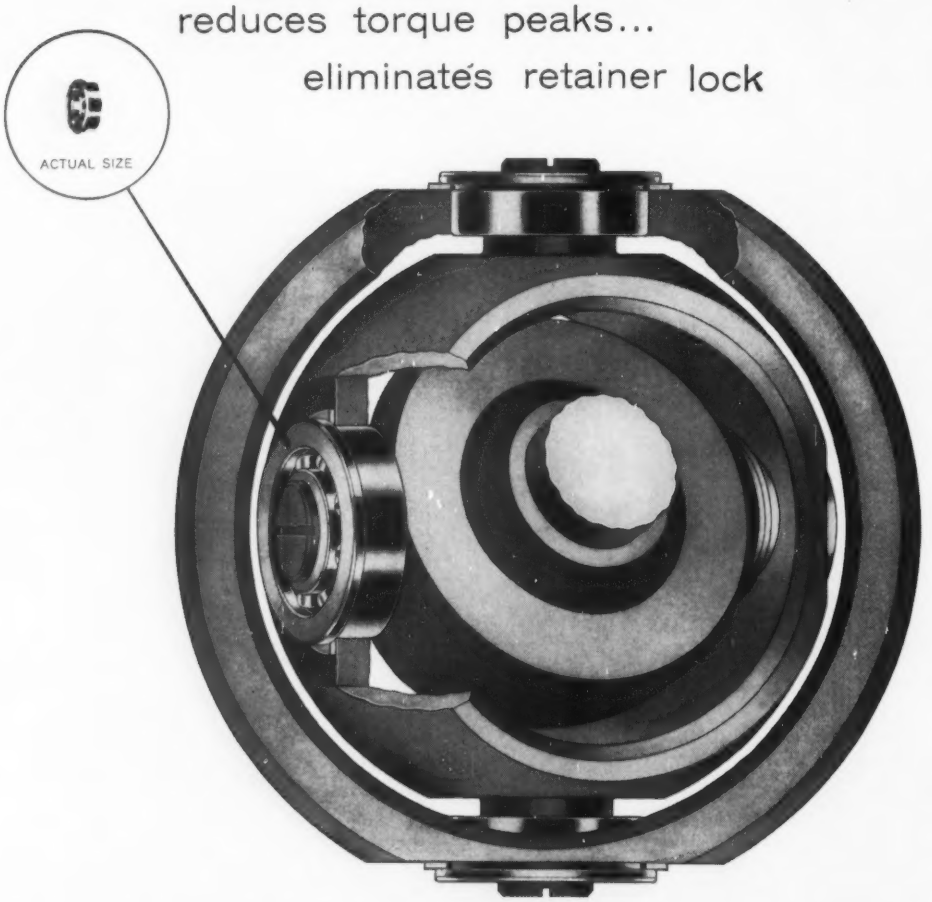
GENERAL ELECTRIC

TO MEET customer emergency requirements, General Electric Tri/Clad '55' motors are frequently shipped by air.

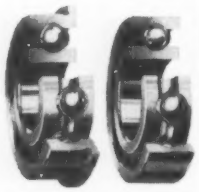


A FULL-LINE OF GENERAL ELECTRIC Tri/Clad '55' motors means you can get the right motor for every application.

BARDEN "W" retainer reduces torque peaks... eliminates retainer lock



Low-torque reliability for gyros, synchros and other torque-sensitive components



"W" retainer bearings are available flanged or unflanged, shielded or open, in sizes most in demand ⅝" O.D. and under. For complete technical information write for engineering data sheet W-1.

An instrument bearing that passes all normal torque tests can develop excessive torque peaks in operation. In gyro gimbals, synchros and similar applications the result is erratic component performance. To solve this reliability problem, Barden developed the "W" ball retainer.

Field tested and proved in actual operation, Barden "W" retainer bearings are specified for a growing number of torque-sensitive applications. • • • *In gimbals on the Sidewinder they contribute to the missile's reliability.* • • • *In attitude gyros they save one manufacturer $100 per unit by reducing costly teardown.*

Like other Barden advances in engineering and manufacturing, "W" retainers answer a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400°F)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
- Concentric rotation (to .00005" max. T.I.R.)

The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.

for reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 208 Park Avenue, Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

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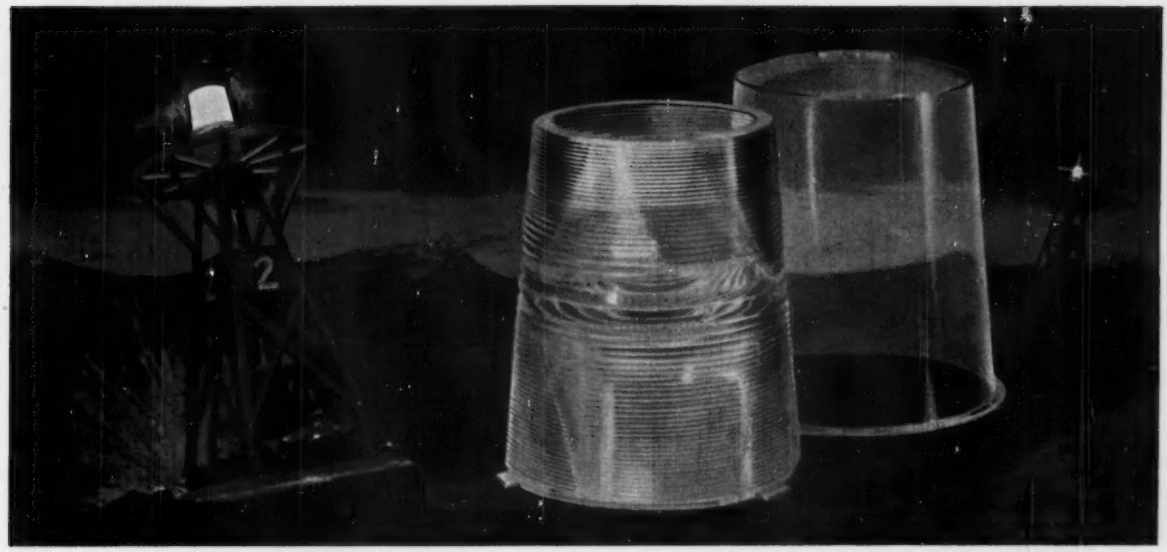
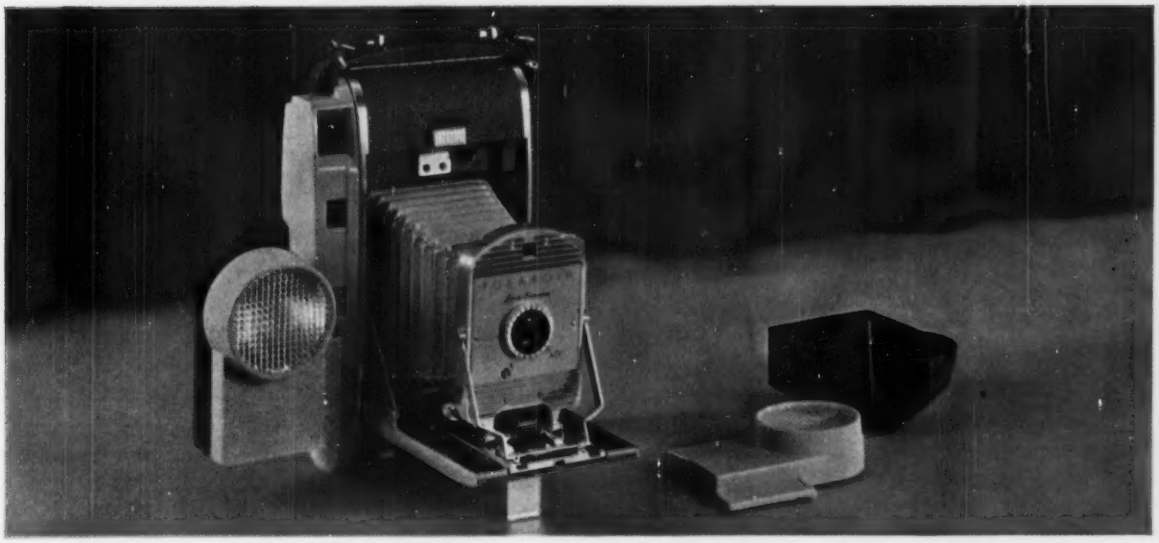


Handsome and Hardworking

Plexiglas...Implex



Flashing lights at sea shine brightly through large lenses and covers molded of PLEXIGLAS® acrylic plastic. The PLEXIGLAS parts are used in navigation lights for the U. S. Coast Guard, at a fraction of the cost and weight of cut glass lenses. Precision molding of the lens pattern gives the PLEXIGLAS lens maximum efficiency in light control, and the material resists weather, breakage and salt water.

Winking lights at home are revolutionizing indoor photography by making indoor pictures without flashbulbs possible, with the new wink-light attachment shown above. Tough IMPLEX®, the high impact acrylic, gives handsome appearance and rugged durability to the housing. PLEXIGLAS is used for the lens.

We will be glad to help *you* use these Rohm & Haas acrylic molding materials—to your advantage.

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Company of Canada, Ltd., West Hill, Ontario.*

Circle 435 on Page 19

After 31 years of continuous growth and

We're changing

The Bendix

To reflect our dynamic growth in such fields as electronics, missiles and space, automotive, weapons systems, computers, machine tools, instrumentation, nuclear technology, hydraulics, meteorology, electrical, marine and others, we are dropping "Aviation" from our corporate name on June 1, 1960. We do not wish to convey the impression that our products and skills are limited to the field of aviation alone, although aviation products accounted for billings of $388,700,000 in 1959.

Today Bendix—through 25 divisions and 16 subsidiary and affiliate companies around the world—serves many fields.

Our success in the rapidly expanding age of aviation has long obscured the fact that the Bendix® automobile starter drive was the company's first major product. Bendix introduced the type of four-wheel brakes that over the years has been used on most makes of cars. Bendix also pioneered automotive power brakes and power steering. Our automotive business in 1959 totaled $114,300,000.

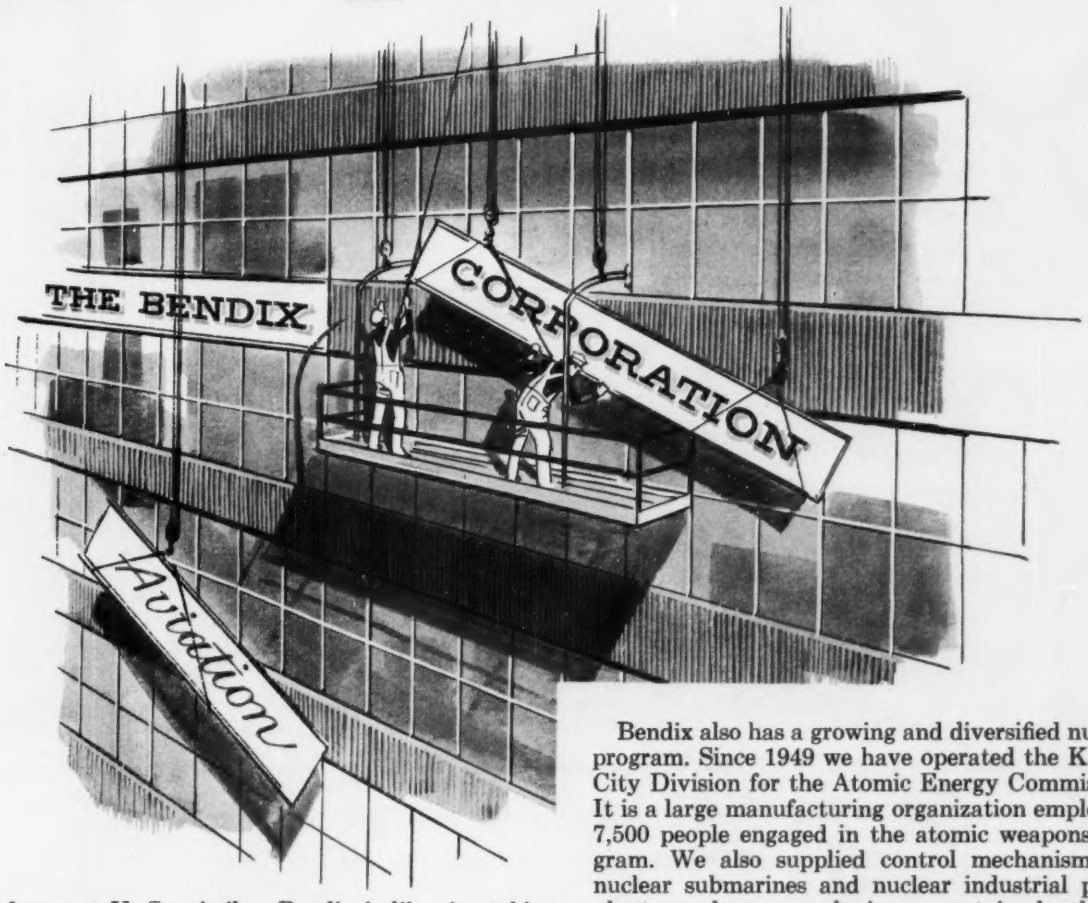
A notable trend in Bendix' recent history is the utilization of electronics in many of our major fields of activity. These range from automobile radios to aircraft and industrial communications and automatic flight controls . . . from electronic computers and data processing to numerical tape control systems for machine tools . . . and from transistors and ship-to-shore telephones to sonic cleaning and undersea sonar detection equipment. Approximately 40% of Bendix products are electronic, including air defense radar which today guards 25 million square miles of the earth's surface.

Missile and space equipment accounted for $103,000,000 of our total business of $689,692,312 in 1959. In addition to being the prime contractor for two important missiles, Talos and Eagle, we are also a supplier of components and sub-systems

diversification as Bendix Aviation Corporation . . .

our name to

Corporation



for most U. S. missiles. Bendix is likewise taking an active part in Project Mercury and in satellite communications. The first is the program to put a man into space. The second will mark a new era in communications by using a satellite in orbit as a relay station for global radio messages between earth stations and aircraft.

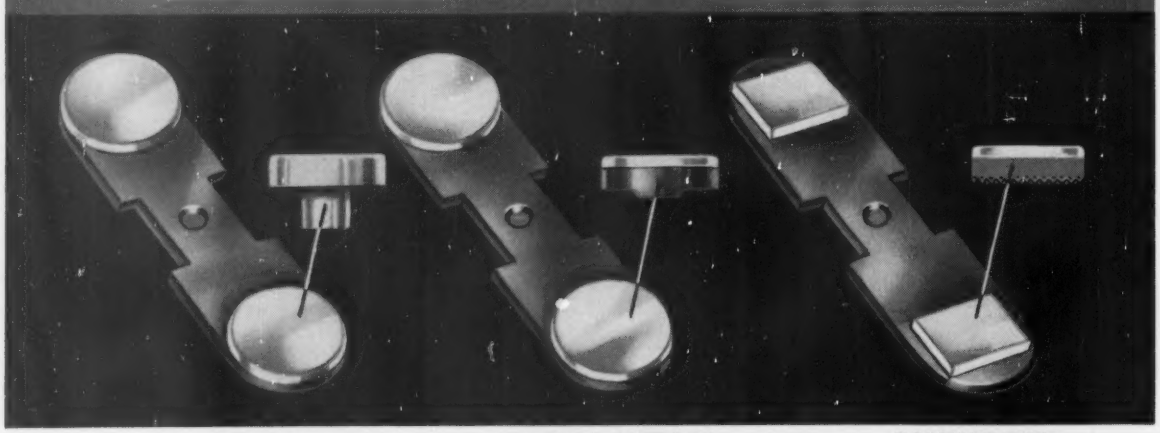
Bendix also has a growing and diversified nuclear program. Since 1949 we have operated the Kansas City Division for the Atomic Energy Commission. It is a large manufacturing organization employing 7,500 people engaged in the atomic weapons program. We also supplied control mechanisms for nuclear submarines and nuclear industrial power plants, and we are playing a part in developing the newest U. S. atomic power plants for aircraft, missiles and space vehicles.

Thus, as we drop "Aviation" from our corporate name, but not from our programs, we face a tomorrow where the range of our opportunities is broadening at a breathtaking rate.

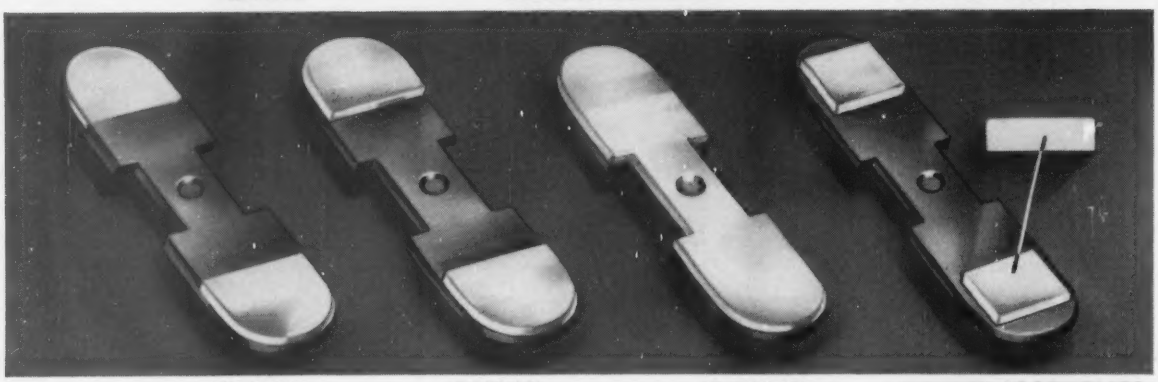
THE Bendix CORPORATION
Fisher Bldg., Detroit 2, Mich.

A thousand diversified products

? Which Assembly is least expensive ?



RIVETS WELDING BUTTONS CONTACT TAPE



STRIPE TOPLAY OVERLAY BRAZED ASSEMBLIES

Have you re-evaluated your designs lately?
Let General Plate provide the right answer . . .

There are many ways to fabricate the same contact assembly . . . but almost in every case there is always *one best, least expensive way.*

The General Plate products group of Metals & Controls Division produces a complete line of contact assemblies and contact materials. Backed by 43 years of metal cladding experience, we have the facilities and know-how to provide the performance required at the lowest cost.

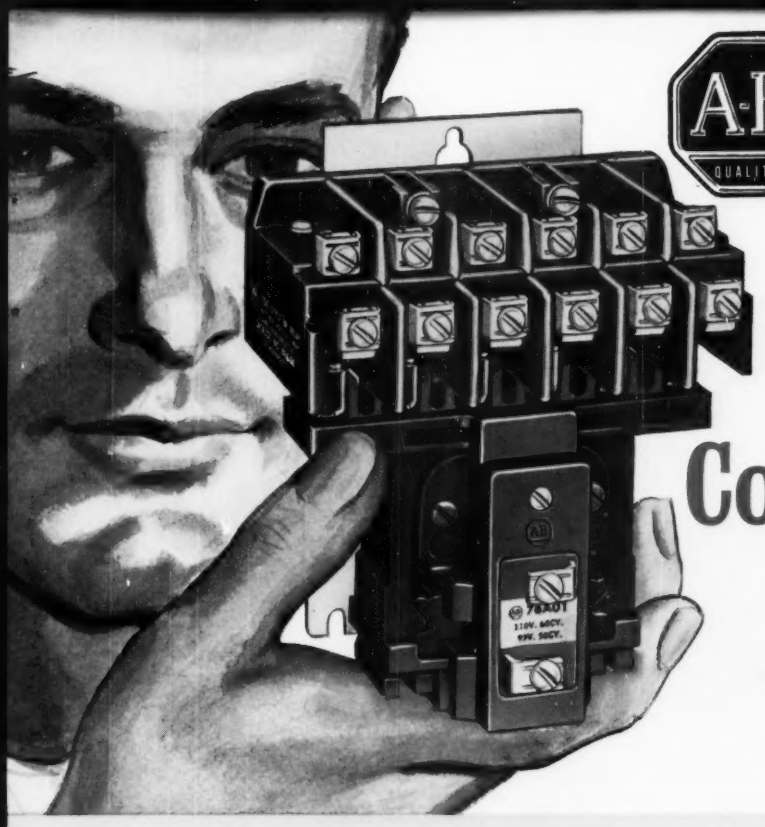
For Example: recently a manufacturer of automotive components, with the help of Metals & Controls Division Engineers, changed his contact design and increased production by 900% at the same time reduced costs proportionately.

It will pay you to investigate General Plate contacts and materials. We offer . . . complete technical information, engineering design assistance, samples, on-time deliveries. Our competent Field Engineers will gladly call at your request and review your current and future designs without obligation. Write today:

TEXAS INSTRUMENTS
INCORPORATED
METALS & CONTROLS DIVISION
805 FOREST STREET • ATTLEBORO, MASS.

General Plate Products: Clad Metals • Electrical Contacts • Truflex® —Thermostat Metal • Gold, Silver, Platinum and other Precious Metal Products

Circle 437 on Page 19 Circle 438 on Page 19→



NOTICE!

60 Second Contact Convertibility

ALLEN-BRADLEY CONTROL RELAYS

can thus easily be changed
from N.O. to N.C. (or vice versa)

Why not give yourself a real surprise! We refer to the ease with which you can convert the contacts of these Allen-Bradley Bulletin 700 Type BR control relays. Using only a screwdriver, contacts can be changed from normally open to normally closed (or vice versa) in seconds—without removing the relay from its mounting—or its wiring. This "on-the-spot" convertibility certainly suggests an appreciable moneysaving reduction in your relay inventories.

Extensive tests have proven conclusively that the Bulletin 700 Type BR relays are good for many—and we mean *many*—millions of trouble free operations. A "built-in" permanent air gap completely eliminates all possibility of magnetic sticking. Naturally, the double break, silver contacts never need attention. Also, the molded coil is your assurance that even the most severe atmospheric conditions cannot cause trouble. Please write for full details on these relays today!

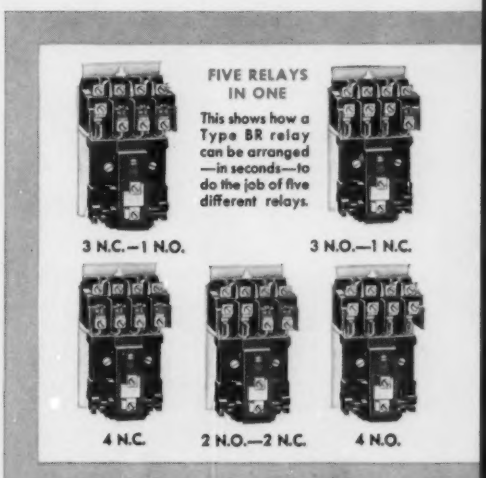
BUT HEAR THIS!

In the event that when "on-the-job" it is discovered that something was either overlooked or added, the standard Bulletin 700 Type BR—either 2, 4, or 6 pole relay—can easily have added to its base, out in the field, either one or two switching poles. It is done as easily as "falling off a log."

General-Purpose
NEMA 1

Explosion-proof
NEMA 7

Waterproof
NEMA 4


FIVE RELAYS IN ONE
This shows how a Type BR relay can be arranged—in seconds—to do the job of five different relays.
3 N.C.—1 N.O.
3 N.O.—1 N.C.
4 N.C.
2 N.O.—2 N.C.
4 N.O.

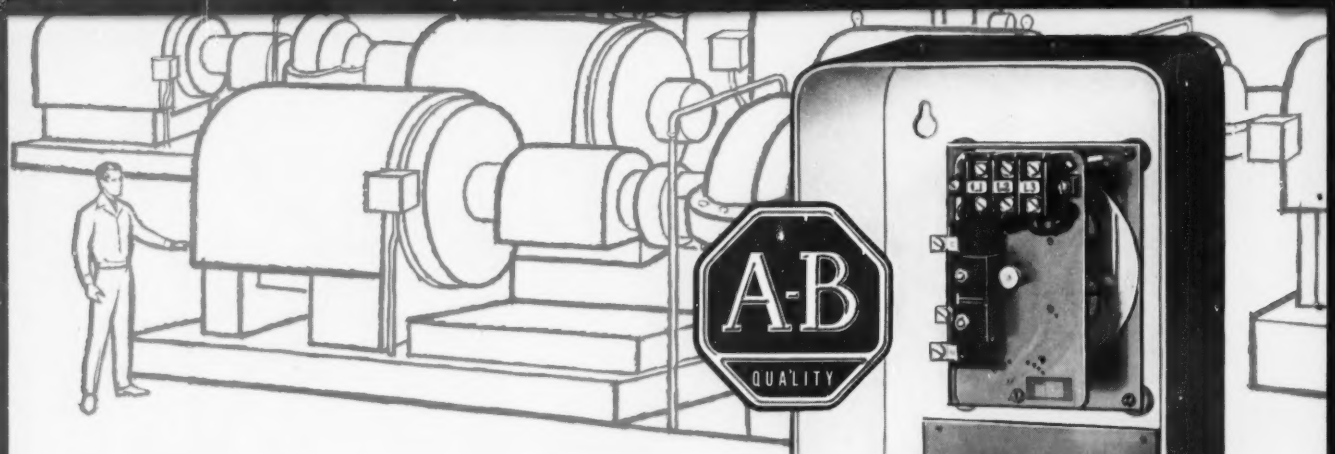
8-60-RN

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



ALLEN-BRADLEY PHASE FAILURE *and* PHASE REVERSAL RELAYS

will provide positive protection for high-horsepower, high-priced motors!

It's sound "economy" to guard your investment in expensive motors and equipment against the extensive damage that can result from a phase failure or phase reversal. Allen-Bradley's Bulletin 812 Style RF relay provides *complete, positive* protection against both of these hazards.

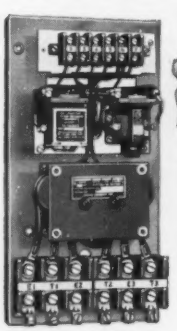
The Bulletin 812 Style F phase failure relay instantly detects *all* open phase conditions on a motor branch circuit and removes the motor from the line—yet is not subject to nuisance dropouts from transient line fluctuations. An unusual feature of this Style F relay is its positive response, regardless of motor load or type of motor branch circuit employed.

The Bulletin 812 Style R phase reversal relay disconnects the motor from the line—whether it is running or not—when a phase reversal occurs on the line side of the relay. Thus, it can be used to protect a single motor or a group of motors. Furthermore, the Style R relay removes the motor from the line should a phase failure occur while the motor is stopped.

All A-B Bulletin 812 relays are completely "fail safe." It will pay you to investigate this economical insurance against the heavy losses that can—and *frequently* do—result from phase failure and phase reversal. Write today!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Bulletin 812 Style RF for Phase Failure and Phase Reversal consists of Style F Phase Failure and Style R Phase Reversal relays in the same enclosure.



Bulletin 812 Style F for Phase Failure

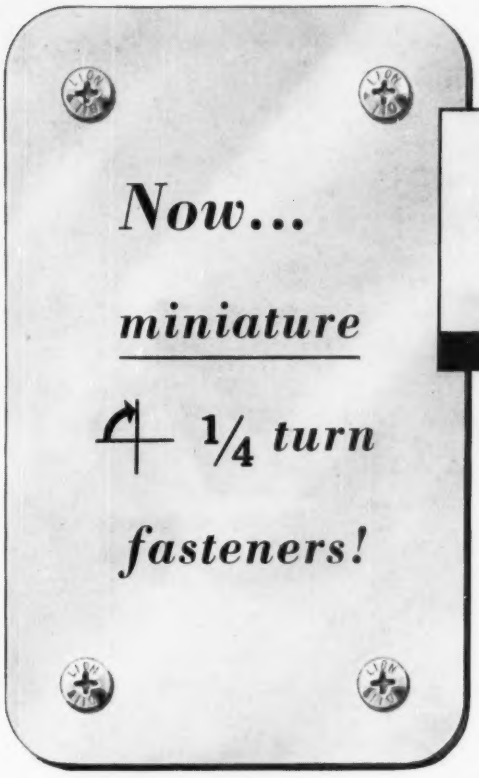
Bulletin 812 Style R for Phase Reversal

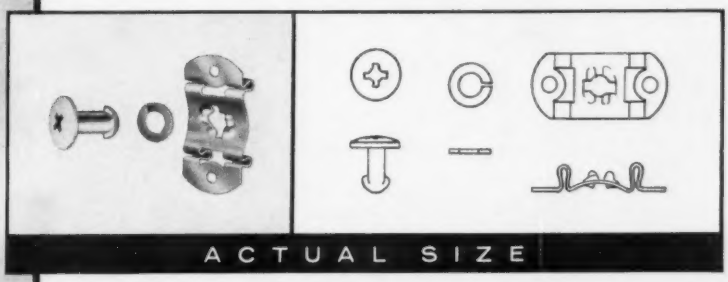
8-60-RM

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control





LION *miniature* FASTENERS

¼ TURN OPEN • ¼ TURN CLOSED

LIGHTWEIGHT • STRONG
MINIMUM ENVELOPE

A new size has been added to the Lion family of quick-opening fasteners . . . a miniature size. Small, compact, yet strong and rugged, these miniatures aid in reducing overall dimensions and weight without sacrificing the important advantages of larger Lion Fasteners.

ALIGNMENT NOT CRITICAL

Stud "floats" to accommodate misalignment. The hole in the sheet for the stud has an area 60% greater than the stud diameter. This allows a .030 float in all directions.

WIDE VARIATION IN STACK HEIGHT

Six different studs accommodate total material thicknesses (both sheets) of .040 minimum to .159 maximum.

Total sheet thickness served by any one stud may vary as much as .019 without affecting operation. A Lion Miniature Stud, specified for a thickness of .0863, for example, will accommodate total sheet thicknesses from .080 to .099.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the exclusive Lion swaged nose design. All the metal is put to work. There are no holes, thin cross pins, or milled slots to weaken the cross-section. Case hardening assures long, trouble-free service without wear.

LARGER SIZES AVAILABLE

Lion Fasteners are also available in two larger sizes—No. 5 (mil spec) and No. 2—to meet the needs of aircraft, missile and ground support equipment. The heads are supplied in a wide variety of styles including oval, flush, wing, ring, notched and knurled.

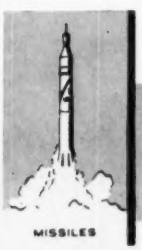
FREE!

FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and many other special fasteners.

Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

©1959



LION *Aviation* FASTENERS

one of the

SOUTHCO LION **FASTENERS**

←Circle 438 on Page 19

Circle 439 on Page 19

Schlieren photograph showing heated air rising from Malleable chain link at 1200° F.

For Hot Parts... Use Malleable

Heat them up, cool them off—ten thousand times. Heat them up, keep them hot—indefinitely... you'll find you can count on Malleable iron castings for an exceptional combination of safety and economy.

New research demonstrates that the rugged room-temperature characteristics of Malleable castings remain virtually unchanged up to 800° F! More important—from 800° F. to 1,200° F., Malleable castings are unique in providing safe, dependable service **without** sudden drop in strength.

Let a nearby Malleable castings producer help you develop better, more economical parts for elevated temperature applications. Send drawings or an outline of your requirements to any of the progressive companies that display this symbol—

MEMBER

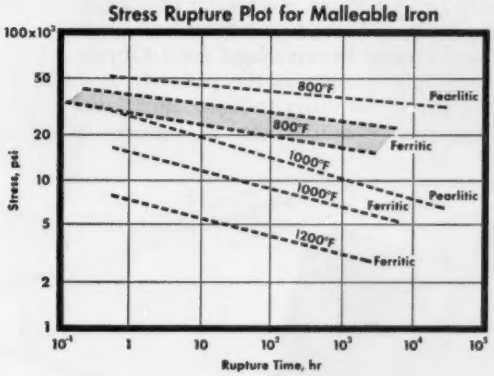
MALLEABLE CASTINGS COUNCIL

For detailed information on "Use of Malleable Castings in Elevated Temperature Applications," contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

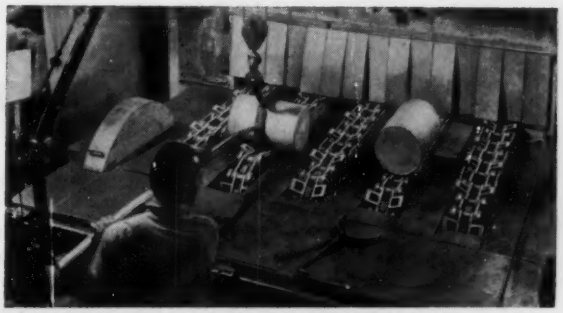
Get Dependable Strength At Elevated Temperatures With Tough, Economical Malleable Castings

Malleable iron castings give you excellent service under rugged conditions at temperatures up to 800F. Even at temperatures as high as 1200F, at reduced stress levels, Malleable castings offer uniformly predictable properties.

Compare these stress-rupture curves for Malleable iron with other ferrous metals. Malleable's are straight, gradually declining curves . . . not curves that break sharply and suddenly downward. With Malleable you can count on long life.



At temperatures from sub-zero to over 800F, Malleable delivers more strength per dollar than any other metal, ferrous or non-ferrous. In addition, your products will profit from Malleable's exceptional machining ease and uniformity, and the efficiency of the casting process.



Eight years of service at 900F without a failure! That's the history of these pearlitic Malleable conveyor chains carrying aluminum billets through a furnace. Similar Malleable chains have been subjected to temperatures as high as 1300F in sheet steel normalizing furnaces for years without failure.

Subjected to dynamic stresses at temperatures from 500 to 750F, these pearlitic Malleable truck and bus diesel engine pistons commonly provide more than 40,000 hours of service . . . over 1,000,000 miles!

Free Engineering Aid — To help you more exactly evaluate the possibilities of producing better products at lower cost with Malleable castings, send for *Data Unit 108—Elevated Temperature Characteristics of Malleable Iron Castings.* Your copy is available from any foundry listed below, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

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Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

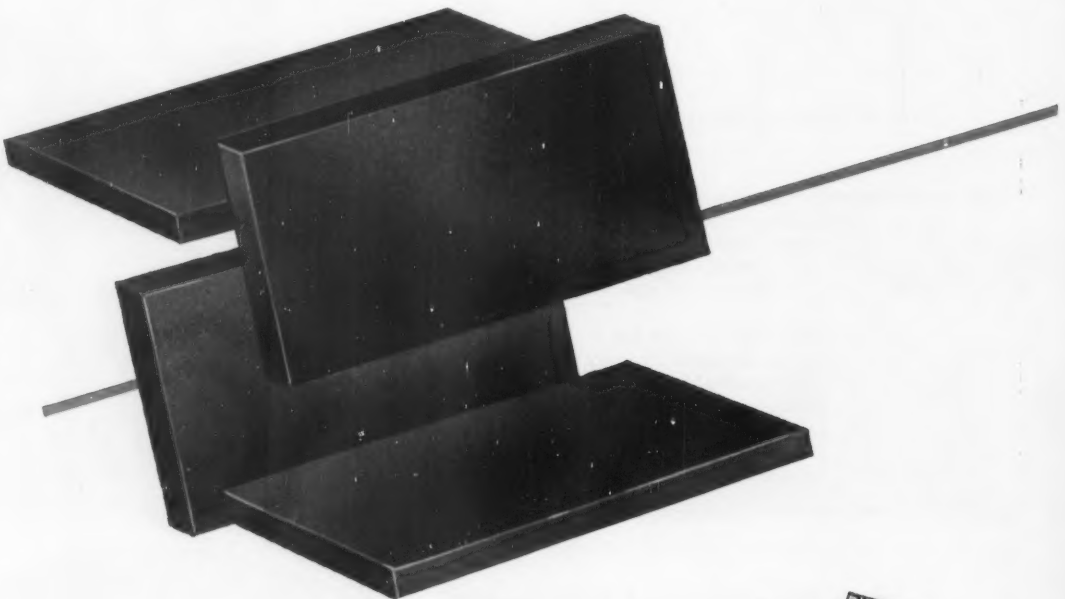
WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Circle 440 on Page 19

GRAPHITAR® VANES
(CARBON-GRAPHITE)

and long life of CONDE

This rotary positive displacement pump, engineered and produced by the Dri-Air Pump Department of the Conde Milking Machine Company, Inc., of Sherrill, N. Y., is designed to deliver clean, dry air or gas for high vacuum and low pressure applications in hospitals, dental offices, chemical or pharmaceutical plants, industrial processing systems and in metalworking plants. Thanks to vanes of GRAPHITAR, the CONDE Dri-Air Pump gives years of trouble-free, continuous operation at maximum recommended vacuum and speed . . . *without lubrication!* The GRAPHITAR pump vanes are self-lubricating and are seated by centrifugal force. Operating with a minimum of friction, they become increasingly efficient as the pump is used. In addition to their self-lubricating properties, the GRAPHITAR vanes are hard, light, non-sticking, non-warping and chemically inert. Perhaps these qualities can be utilized to advantage in your products.



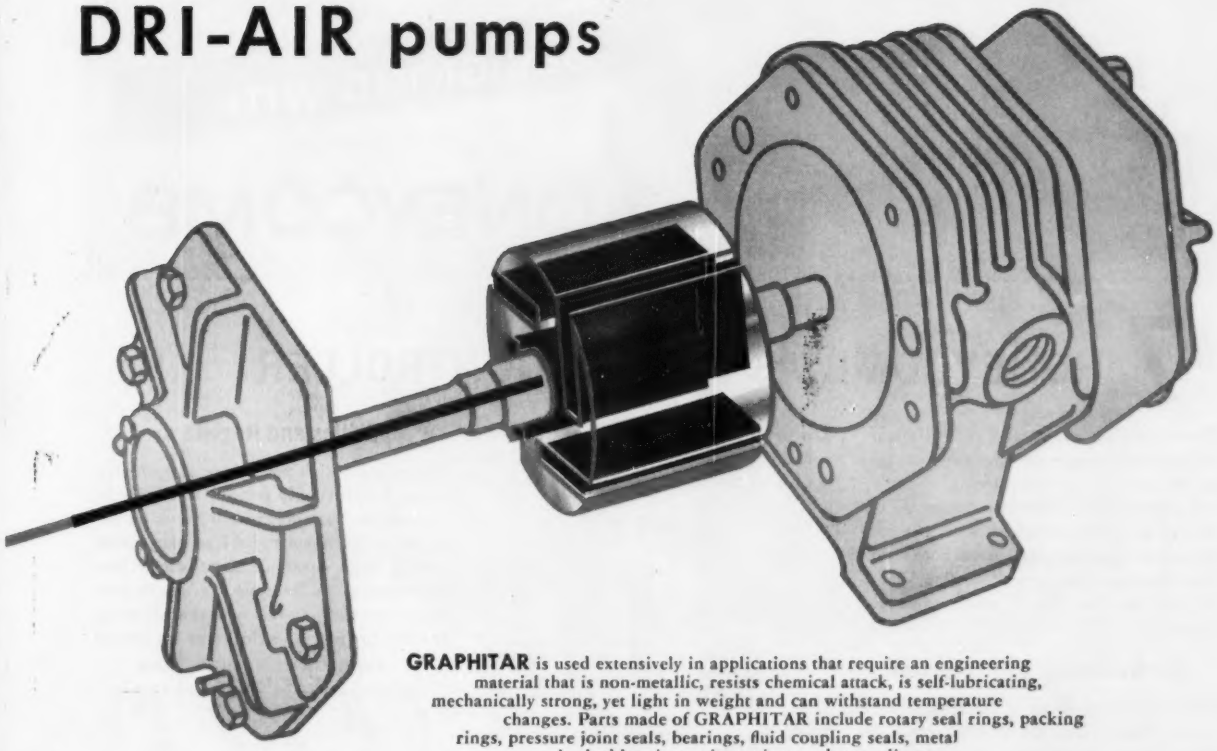
Bulletin #20 includes detailed design data along with properties, characteristics and typical applications of GRAPHITAR. Write for your free copy. If you have questions concerning the incorporation of GRAPHITAR parts in your products, our engineers will be glad to assist you.

THE UNITED STATES

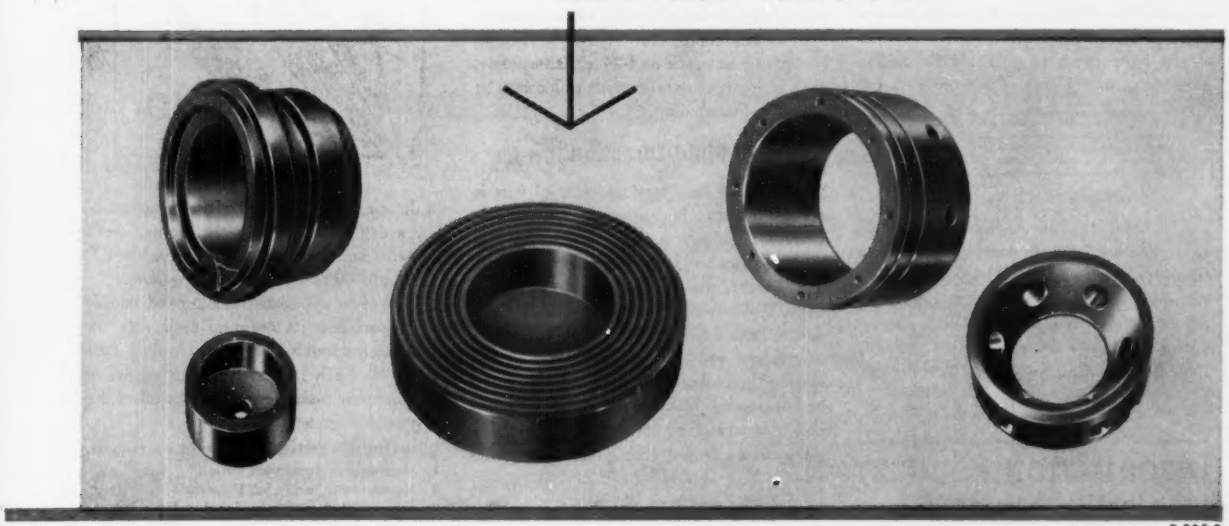
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

help insure efficiency

DRI-AIR pumps



GRAPHITAR is used extensively in applications that require an engineering material that is non-metallic, resists chemical attack, is self-lubricating, mechanically strong, yet light in weight and can withstand temperature changes. Parts made of GRAPHITAR include rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings, piston rings and pump liners.

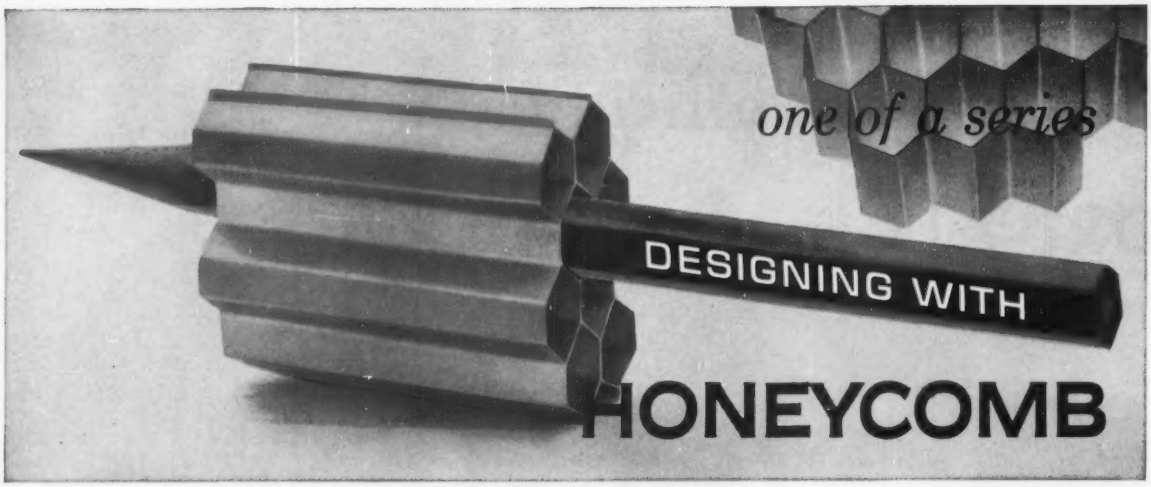


R-285-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 441 on Page 19



#7 HONEYCOMB AS A FLOW CONTROLLER

The clean edges and parallel cell orientation of expanded honeycomb offer new solutions to the problem of straightening, changing the direction of, or otherwise controlling the flow of air, other gases, and liquids. In general, directional characteristics of honeycomb have three separate uses: deflecting, directing and guarding (as in grilles and registers).

Air Deflection and Direction

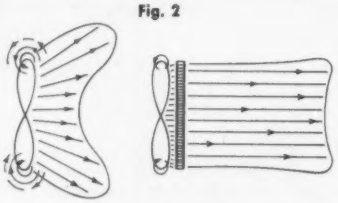
When a stream of air is intercepted by a piece of honeycomb, the air is uniformly deflected into a direction parallel to the cell axes, and the direction of flow of the stream of air is controlled by the relative position of the honeycomb (Fig. 1). This unique property of honeycomb also permits its use

Fig. 1

as a flow straightener immediately downstream from a fan blade. Honeycomb almost entirely removes the turbulence created by the rotation of the fan and allows the air stream to maintain a much higher velocity than would otherwise be possible (Fig. 2).

The exact degree of improvement depends upon the proximity of the honeycomb to the fan blades, the amount of turbulence caused

Fig. 2



by the fan, and whether it is in open air or surrounded by a duct. Honeycomb's low resistence characteristic can be advantageously used to either raise flow rate with existing blowers by as much as 50% or, alternately, to reduce power requirements of blowers by an equivalent amount.

Fluid Direction

Straightening or directionalizing of flow is not restricted to fans operating in air; this property of honeycomb can also be applied to other gases and liquids. It has been found, for instance, that the addition of a honeycomb flow straightener immediately upstream from a liquid flow meter contributes to efficient and accurate operation of the meter at much higher flow rates. Honeycomb was chosen for this assignment because of its ability to straighten flow, plus the extremely low pressure drop resulting from its installation.

Grilles and Registers

Honeycomb's high percentage of open area makes it particularly suitable as a grille or register. Because honeycomb has a unique ability to attenuate radio frequency noise, several large electronic installations have successfully used honeycomb grilles in cooling air openings. In this type of application, the cell size and slice thickness are critical

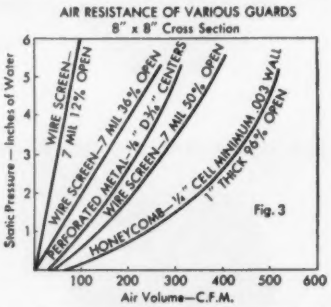


Fig. 3

in determining the range of frequencies below which complete blocking occurs. Light transmission is also made possible when RF filters are fabricated from honeycomb.

In all of the applications mentioned, honeycomb performs its required task with an absolute minimum obstruction to fluid flow (Fig. 3). Such improved design efficiency can, in many instances, more than offset the cost of the honeycomb.

Others in this series. Copies sent on request.

1. **Honeycomb Sandwich Panels**
2. **Honeycomb Sandwich Materials**
3. **Successful Honeycomb Sandwich Design**
4. **Honeycomb Design Characteristics**
5. **Honeycomb as an Energy Absorber**
6. **Varieties of Honeycomb.**

4283

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Send to Hexel Products Inc. Dept. 5-C
2332 Fourth Street, Berkeley 10, California.

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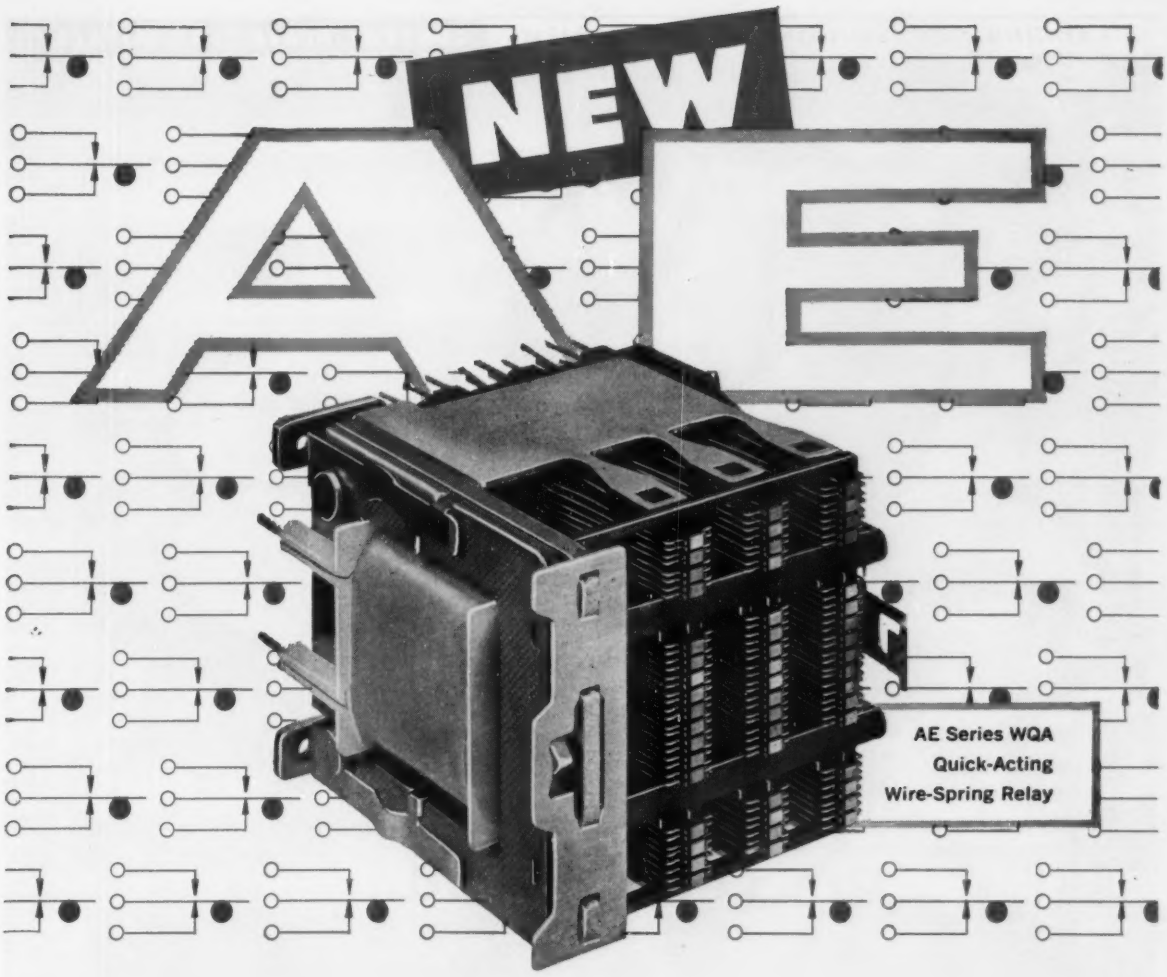
HEXCEL® PRODUCTS INC.

World's Largest Manufacturer of Honeycomb Products and Materials

Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.

Distribution throughout the United States and Canada

Circle 442 on Page 19



TO THE ENGINEER

who wants to transfer 51 circuits simultaneously

If you need simultaneous transfer of a large number of circuits without fail, take a look at AE's new WQA relay. It will do the work of four or more heavy-duty, general-purpose relays each with maximum spring pile-ups, and sustain 50 million or more operations without readjustment.

In the WQA relay, all moving springs pass through holes in a unique actuating "card." Moved directly by the armature, the card in turn actuates all the moving springs. This method of operation pre-establishes exact timing and sequence of all spring operations, and at the same time assures perfectly synchronized "break-before-make" on all circuits.

Contact capacities on WQA relays can be custom-tailored to your needs, with either one, two or three levels of contact assemblies available, each with a capacity of 17 Form C combinations. Other Forms available.

Our circuit engineers will be pleased to work with you in adapting the WQA to your specific design. Or, if you wish, they'll take on the complete packaging job.

If you'd like more information on the WQA relay, address your request for Circular 1957 to: Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AUTOMATIC ELECTRIC

Subsidiary of

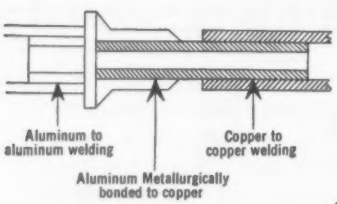
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 443 on Page 19

CREATING NEW SOLUTIONS TO NEW PROBLEMS | GENERAL PLATE CLAD METALS

One of series illustrating how General Plate Clad Metals help uncover new horizons in one of many fields of engineering accomplishments: REFRIGERATION



ALCUPLATE® (aluminum clad copper) fabricated into tubing connector solves mechanical joining problem. Aluminum and copper are metallurgically bonded and permit aluminum to aluminum and copper to copper welding for a corrosion-free seal.

New Products made with New Materials... New Processes...

USED IN NEW AND DIFFERENT WAYS

Among the important contributions to the success of refrigeration is the use of ALCUPLATE® (aluminum clad copper) fabricated into a tubing connector. In this small part composed of clad metal, the advantages of welding copper to copper and aluminum to aluminum are combined to create a perfect corrosion-free seal. This makes it possible to eliminate galvanic corrosion and subsequent leakage resulting from bonding copper and aluminum tubing using cold welding techniques.

General Plate Alcuplate is but one of over 400 different combinations of clad metals available which are finding wide use in industry after industry. New combinations are being developed constantly.

No matter what your metal problem, it will pay you to consult with Metals & Controls Division Engineers. Their vast experience in cladding precious to base or base to base metals can overcome your metals engineering problems with multiple property requirements . . . often reduce costs, too. Write today.

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General Plate Products: Clad Metals • Electrical Contacts • Truflex® —Thermostat Metal • Gold, Silver, Platinum and other Precious Metal Products

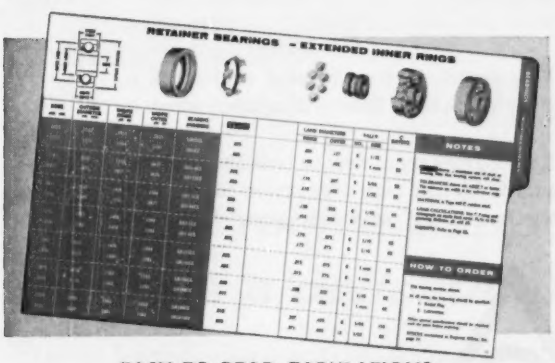
"...NEW MANUAL EXPANDS INFORMATION ON MINIATURE & INSTRUMENT BALL BEARINGS..."

By **GEORGE HAMPSON**, *Vice President-Sales, New Hampshire Ball Bearings, Inc.*

"... this 'Design & Purchasing Manual' replaces the first-of-its-kind 'Technical Data and Catalog' book NEW HAMPSHIRE published in 1957. As the 'Technical Data' (black cover) was then, we believe the 'Manual' (green cover) is now, the most complete source of information on miniature and instrument ball bearings in print. About 50 pages larger than the old book, the 'Manual' was expanded that much to include information developed since 1957 on ordering, maintaining, fitting, lubricating and testing miniature bearings."

QUALITY — AND ASSURANCE

"The significance of ABEC Class 7 tolerances to running quality of instrument bearings is covered in one section with a brief, to-the-point explanation of how improved bearing geometry helps the design and quality control engineer. A pictures-and-words story describes NEW HAMPSHIRE's Quality Assurance by which this high standard for miniature bearings is maintained in production. The equipment used, and how used, is fully described. Testing geometry and finish, cleaning and lubricating, functional testing of bearings, and metal research are some of the subjects covered."



EASY-TO-READ TABULATIONS

"An even easier-to-read tabulation form is used to list NEW HAMPSHIRE Bearings in Bore/OD/Width sequence for quick identification and selection when ordering or writing specifications. Three hundred seventy bearings are so listed, including NEW HAMPSHIRE wafers, the narrowest shielded retainer bearings possible for given Bore/OD combinations, and developed especially for manufacturers of synchros, servos, small motors, potentiometers, miniature gear trains, and other products where space-for-bearings is a problem."

BEARING NUMBERS EXPLAINED

"The 'Design & Purchasing Manual' includes a section on Designation, Packaging and Marking in which NEW HAMPSHIRE Bearing number symbols are explained, methods of packaging available from NEW HAMPSHIRE are described, and materials identification codes listed. Study of this section can work savings of money and time by minimizing the necessity of returning mistake-ordered bearings. In addition, simple HOW TO ORDER instructions are included on every page of bearing tabulations.
A Table of Weights is provided to assist those responsible for systems design and planning to compute weights of the NEW HAMPSHIRE Bearings specified and included."

ENGINEERING BULLETINS EXPANDED

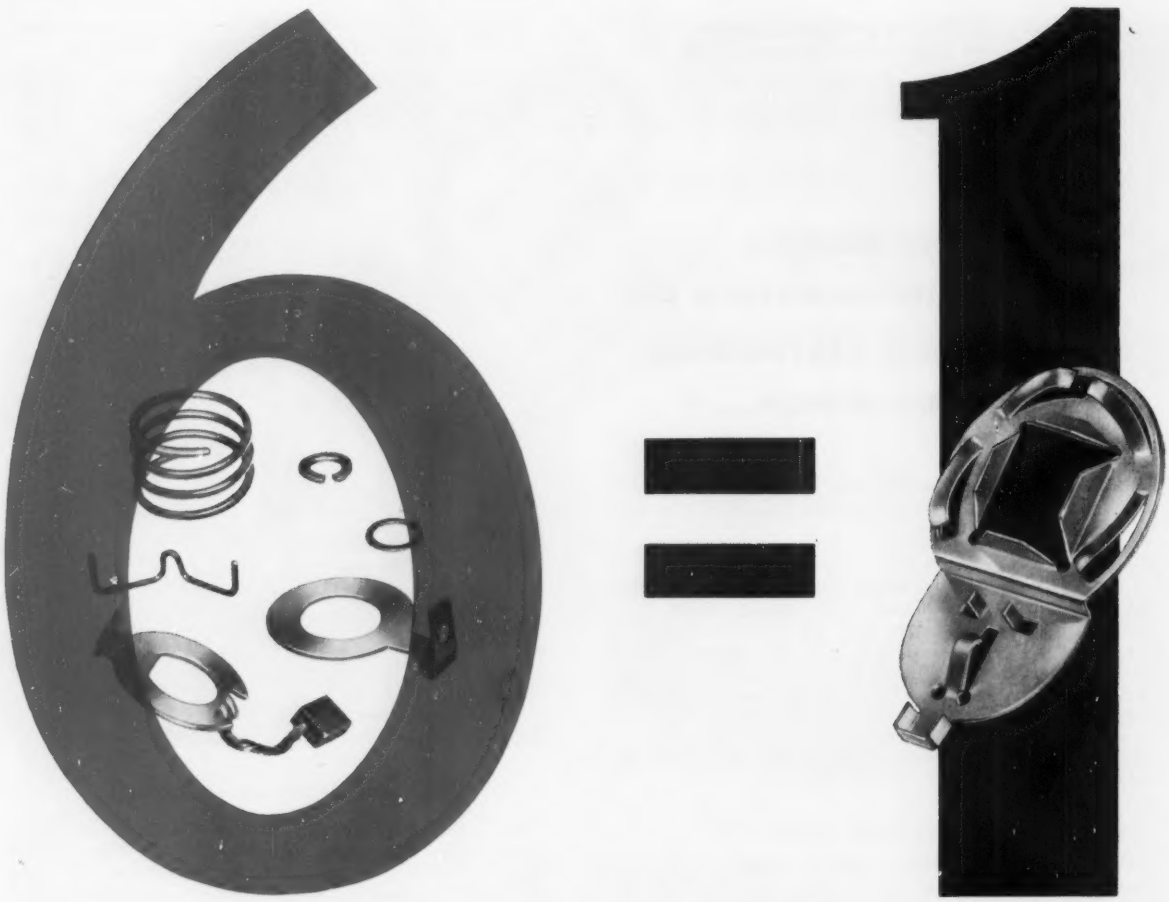
"The Engineering Bulletins have been expanded and brought up-to-date to inform designers, engineers and quality control personnel of the latest developments related to Lubrication, Load Ratings, Fits, Speed, and other factors affecting performance and life of instrument bearings. There are now 22 Bulletins on as many subjects, including the two most recently developed, Duplex Bearings, and Bearing Roundness —one hundred seventeen pages of technical information on miniature and instrument ball bearings compiled and written by Bearing Engineers."

REGISTERED COPIES AVAILABLE

"The 'Design & Purchasing Manual' should be in the library of every designer, draftsman and buyer specifying or purchasing miniature and instrument ball bearings. Each copy is registered to its recipient. Your name and title sent to us on your company letterhead will bring your copy to you by return mail."

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Circle 445 on Page 19



with re-design 'rithmetic

One flat spring now does the work previously required of the six parts shown—and greatly simplifies assembly, too. This single multi-purpose spring (a) holds a carbon brush in a rheostat, (b) applies pressure on the wire windings, (c) provides friction detent action, (d) acts as a retainer on the rotating shaft.

How did this come about? The maker of the rheostat undertook a complete redesign analysis, called in an A.S.C. Spring Engineer when it concerned the spring.

Early consultation with A.S.C. springmakers in new or redesign projects gives greater range to plans, safeguards against high production costs. Our booklet, "Designing Springs for Performance," may help you. Write for your copy.

5902

Associated Spring Corporation

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Travelers from every part of the globe rank The Golden Door at New York's Idlewild International Airport as one of the world's most distinguished restaurants. Fenwal THERMOSWITCH® Units help maintain this enviable reputation.

Precise temperature controls a delicate art at The Golden Door

Preparing fine cuisine is a delicate art. Nothing can be left to chance. That's why at The Golden Door restaurant Fenwal THERMOSWITCH Units are relied upon for precision cooking temperature control.

Installed in this famous restaurant's cooking equipment, these Fenwal THERMOSWITCH Units help prepare succulent meats and a mouth-watering array of delicious sea foods. Fenwal THERMOSWITCH Units control the precise temperature that brings out the best flavors of every international dish listed on The Golden Door's six-language menu.

In almost every area of temperature control — from food preparation and jet engine protection — to fire detection and space exploration — Fenwal is a major factor in temperature control. Fenwal Incorporated, 196 Pleasant Street, Ashland, Massachusetts.

Fenwal

CONTROLS TEMPERATURE PRECISELY

Circle 447 on Page 19

The most efficient, 2-stage air filter today is made by PUROLATOR

Simplicity of design makes the first cost of Purolator's new dry-type two-stage air filter as low as any 2-stage filter on the market. Yet it filters better than any other—99.98% efficient. Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic-impregnated cellulose. Both elements are rated from 450 to 1150 cfm, with exceptionally low initial restrictions. Mounting straps, rainhoods and outlet adapters are available for field installation. The filter comes in all the most-used sizes.

For more information write to Purolator Products, Inc., Department 3450, Rahway, New Jersey.

Purolator Products, Inc.
Dept. 3450, Rahway, New Jersey

Please send me complete data on the new Purolator two-stage filter series.

Name_____ Title_____

Company_____

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City_____ Zone_____ State_____

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

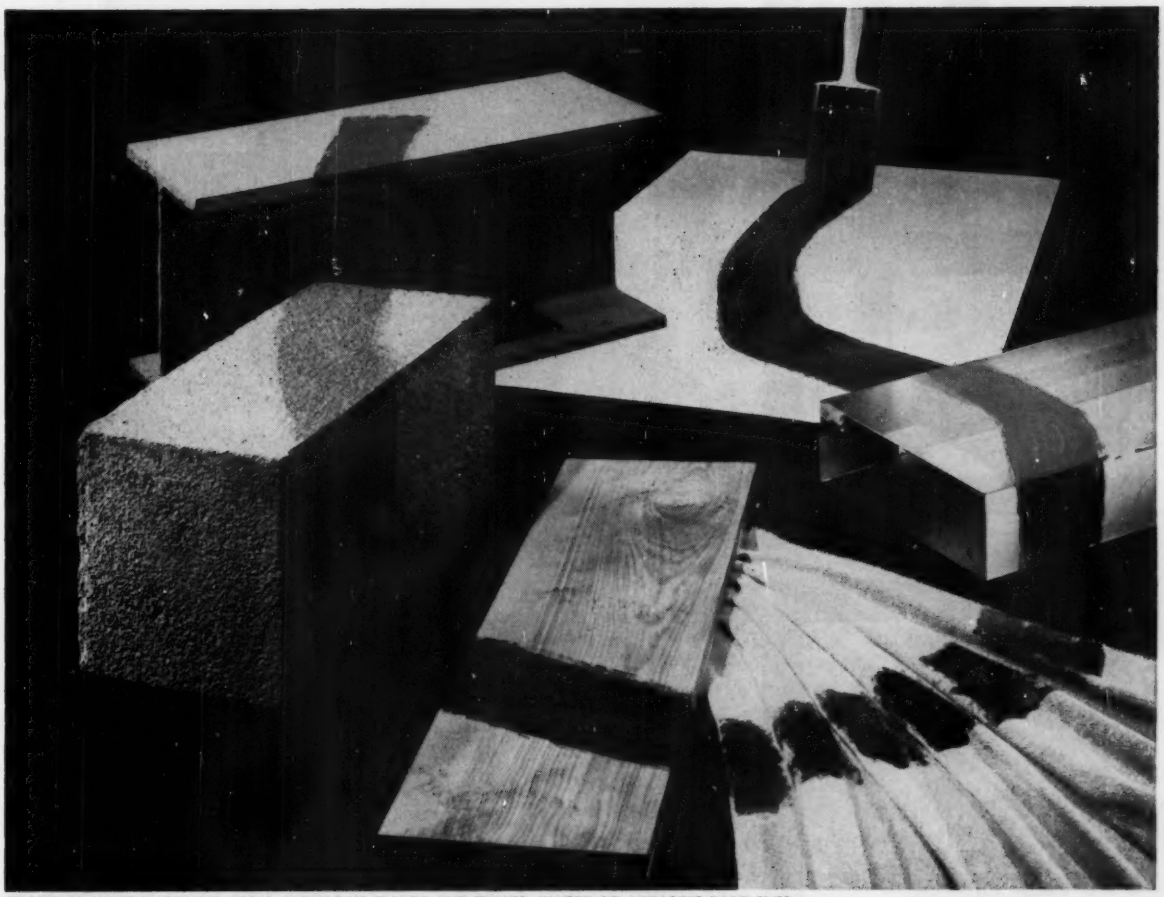
RAHWAY, NEW JERSEY AND TORONTO, CANADA

Circle 448 on Page 19

NEWEST WEAPON IN THE WAR AGAINST CORROSION AND ABRASION!

Coro-Gard® 1706

BRAND PROTECTIVE COATING



PROTECTS MOST SURFACES FROM CORROSIVE FLUIDS AND FUMES, WATER OR ABRASIVE PARTICLES

From the Research Laboratories of 3M comes a remarkable new coating to fight corrosion—CORO-GARD 1706 Brand Protective Coating. This neoprene rubber based coating air-cures to a tough, rubbery, protective film with exceptional resistance to corrosive fluids and fumes, water and abrasion. It maintains exceptional adhesion, flexibility, corrosion and abrasion resistance even after these strenuous test conditions: 2000-hour salt-spray attack; 20 weeks' submersion in 20% solution of hydrochloric acid; six-month weather exposure in Miami, Florida.

CORO-GARD 1706 Coating speeds production, provides unusually high coverage to cut costs. It brushes as easily as paint, is self-priming, yet goes on vertical surfaces with minimum sagging. For steel, aluminum, wood, concrete, cloth and some plastics—wherever corrosion or abrasion must be fought—specify new CORO-GARD 1706 Coating. It provides maximum protection at low cost.

For complete performance data without obligation, write today on your company letterhead to: AC&S Division, 3M Company, Dept. SBR-50, St. Paul 6, Minn.

"Coro-Gard" is a reg. TM of 3M Co.

ADHESIVES, COATINGS AND SEALERS DIVISION

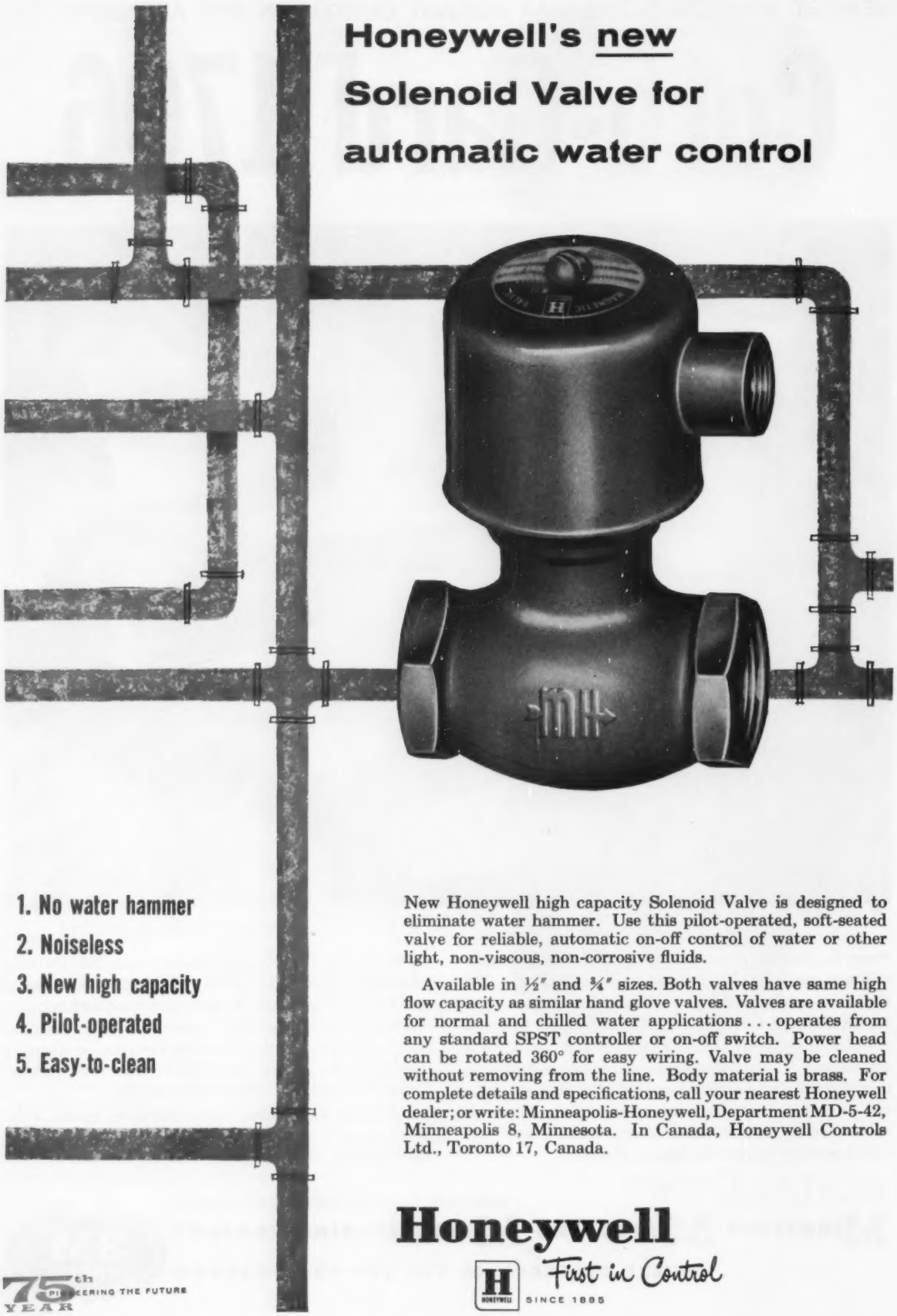
MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 449 on Page 19

Honeywell's new Solenoid Valve for automatic water control



1. No water hammer
2. Noiseless
3. New high capacity
4. Pilot-operated
5. Easy-to-clean

New Honeywell high capacity Solenoid Valve is designed to eliminate water hammer. Use this pilot-operated, soft-seated valve for reliable, automatic on-off control of water or other light, non-viscous, non-corrosive fluids.

Available in ½" and ¾" sizes. Both valves have same high flow capacity as similar hand glove valves. Valves are available for normal and chilled water applications . . . operates from any standard SPST controller or on-off switch. Power head can be rotated 360° for easy wiring. Valve may be cleaned without removing from the line. Body material is brass. For complete details and specifications, call your nearest Honeywell dealer; or write: Minneapolis-Honeywell, Department MD-5-42, Minneapolis 8, Minnesota. In Canada, Honeywell Controls Ltd., Toronto 17, Canada.

Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

Circle 450 on Page 19

CHOICE OF BUILT-IN VALVES GIVES CONTROL FLEXIBILITY

SINGLE AIR CONNECTION SIMPLIFIES INSTALLATION

RUGGED CONSTRUCTION ASSURES LONG LIFE

160 BELLOWS SALES AND SERVICE FIELD ENGINEERS

■ There are one or more Bellows-Valvair Field Engineers in every industrial area of the United States and Canada. They will be happy to work with you in applying "Controlled-Air-Power" to your machine designs. They are listed in their local phone directories both under "The Bellows Co." and "Valvair Corp."

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Four reasons why THE BELLOWS AIR MOTOR® stands first with design engineers

In designing for air cylinder operation the engineer wants first of all sure, positive control, easily interlocked to related machine movements. **He has it in The Bellows Air Motor.**

He wants simple installation, uncomplicated by cumbersome piping. **He has it in The Bellows Air Motor.**

He wants rugged construction — an air cylinder that will stand up day in and day out with minimum requirements for service and repairs. **He has it in The Bellows Air Motor.**

But he also wants the knowledge, if service should ever be needed, that it is quickly available wherever his machine may go. **He has it in The Bellows Air Motor.**

This free booklet offers interesting data for the design engineer. Write for it today. Address Dept. MD-560. Ask for Bulletin BM-25. Bellows-Valvair, Akron 9, Ohio. In Canada: Bellows-Valvair, Ltd., Toronto 18, Ont.

Bellows-Valvair

The Bellows Co. • Valvair Corp. Akron 9, Ohio

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WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

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WH60-14

SLEEVE OR BALL BEARING
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING
You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays drippproof.

NEOPRENE CUSHIONING RING
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.

Machine tools using VICKERS hydraulics maintain precision tolerances on Ford Falcon engines

At Ford Motor Company's Lima, Ohio, plant you'll find the newest techniques and finest equipment being used to produce the six-cylinder, high efficiency, overhead valve engine developed specifically for the new Falcon. And, coincidentally, you'll find many of the machine tool builders have equipped their modern machines with Vickers hydraulics.

Modern production equipment and Vickers hydraulics just go together naturally. Machine builders and users know these pumps, motors and control elements can't be beat in design features and quality of manufacture.

You get "extra" planning help from sales engineers who are hydraulic specialists responsible for the products of a single manufacturer. Skilled technicians who are always near at hand assure better service, too.

Get more details on the most complete line of modern industrial hydraulic equipment available anywhere by writing for Bulletin 5001C.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
DETROIT 32, MICHIGAN

8608

Machine tool builders using Vickers components at the Falcon engine plant

Apex Corporation
Bilt-Rite Tool Co.
Buhr Machine Tool Co.
Can-Tec Division Centri-Spray Corp.
Colonial Broach & Machine Co.
The Cross Co.
Ex-Cell-O Corporation
Greenlee Bros. & Co.
Holcroft & Company
Industrial Metal Products Corp.
The Ingersoll Milling Mach. Co.
Kent-Owens Machine Company
H. R. Krueger & Co.
F. Jos. Lamb Co.
Landis Tool Company
LaSalle Machine Tool, Inc.
The R. K. LeBlond Mach. Tool Co.
Leland Detroit Mfg. Co.
Micromatic Hone Corporation
Morris Machine Tool Co.
The Motch & Merryweather Machine Co.
Snyder Corp.
Sundstrand Machine Tool Division of Sundstrand Corp.
Surface Combustion Division of Midland-Ross Corp.
Tocco Division The Ohio Crankshaft Co.
Turner Brothers
Wilson Automation Co.

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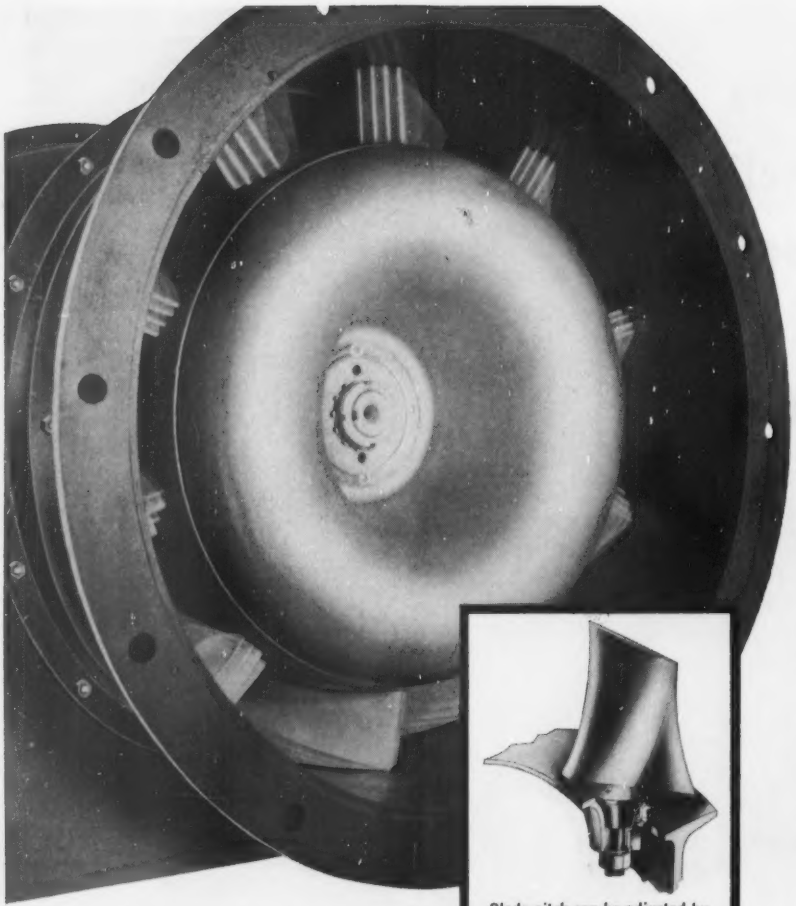


Multiple exposure shows fan blades through the full range of pitch changes.

Blade pitch can be adjusted by loosening one nut, resetting the blade to desired position on calibrated scale, and retightening the nut.

Joy Design Means:

MINIMUM POWER CONSUMPTION WITH VARIABLE FAN OUTPUT

Blade pitch on Joy Axivane® Fans can be adjusted easily. This means that the volumetric output of Joy fans can be varied by as much as ± 20% without any sacrifice of fan efficiency, and therefore with minimum power consumption. And with no efficiency losses such as are encountered with dampers and variable inlet vanes. (Where efficiency losses may be tolerated, the volumetric output may be changed by as much as 400%.)

Even at full load, Joy Axivane Fans are more efficient than propeller, tube-axial and centrifugal fans. The direct drive achieved by mounting the motors inside the fan housings eliminates drive losses, and the vane-axial design gives maximum aerodynamic efficiency. Mounting the motors in the housings also makes the Joy Axivane Fans more compact, and less costly to install.

Fans available range from types which weigh as little as a pound and have a diameter of a few inches, up to some which weigh tons and have diameters up to twelve feet. If you need spot cooling, area ventilation, or any movement of air, Joy can supply the most efficient answer.

For complete information, write for Bulletin 1198-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 454 on Page 19

GENERAL ELECTRIC

Developed Exclusively for Tri-Clad* '55' Motors

NEW 'THERMO-TECTOR' SYSTEM POSITIVELY

ELIMINATES OVERLOAD BURNOUT

Allows Maximum Motor Output — Safely!

Now—Tri-Clad '55' motors have simple, direct-acting thermal protectors that *positively* end winding failures from overloads!

New Thermo-Tector heat-sensing switches buried in stator windings react *instantly* to prevent heat damage. Unique Thermo-Tector "anticipation" feature varies motor shutoff point according to rate of winding heat rise. This ends need for operating safety margin.

Thermo-Tector system uses no costly amplifying relays or special circuitry, works with any General Electric motor controller.

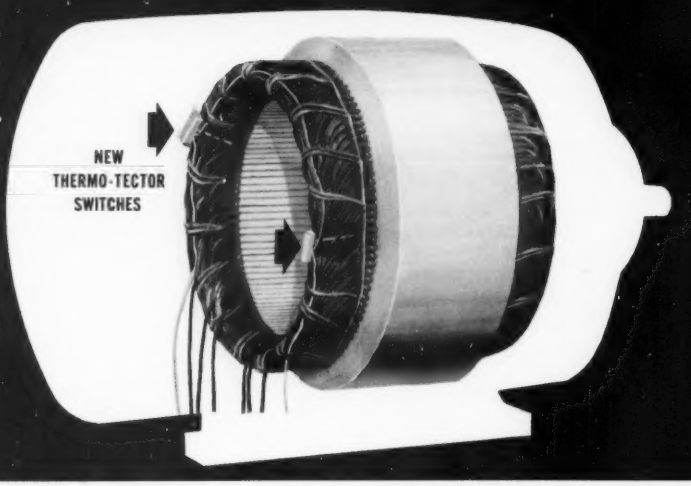
*Registered Trade mark of General Electric Co.

TURN PAGE FOR FURTHER INFORMATION

NOW!

GET MAXIMUM MOTOR OUTPUT WITH NO DANGER OF OVERLOAD BURNOUT!

New THERMO-TECTOR System Operates IN THE STATOR . . . Protects Under All Conditions!



You get *full output* from Tri-Clad '55' motors with Thermo-Tector protection. No operating "safety margin" is necessary since Thermo-Tector switches react instantly to prevent damage from *any* type of winding overload. New General Electric Thermo-Tector switches—buried deeply in the coils of the Tri-Clad '55' motor—are so durable they handle size 4 contactor coil current with *no costly amplifying relays.* Any conventional G-E motor controller works with the Thermo-Tector system.

Thermo-Tector protection is available on *all* Tri-Clad '55' motors in frames 254U-445U. For more information, contact your G-E Apparatus Sales Office or write for Bulletin GEA-7092, Section 866-2, Schenectady 5, N. Y.

SMALL AC MOTOR & GENERATOR DEPARTMENT

GENERAL ELECTRIC

Circle 455 on Page 19

Now you can get standard sizes in C/R End Face Seals!

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

Write for your free copy of this new C/R Bulletin ⟶

Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

- Size range table in two series — long and short — from ¾ to 4 inch shaft diameter.
- Size range table on mating rings.
- Typical seal installations for internal and external pressure.
- Special instructions on how to order.

C/R
STANDARD
END FACE SEALS
maximum sealing efficiency in minimum space
• ¾ to 4 inch shaft sizes
• pressures to 500 psi.
• temperatures to 500° F.
• peripheral speeds to 15,000 FPM.
• external or internal pressures
2 complete series . . . long and short . . . pre-engineered to meet the widest possible range of sealing requirements. Standard mating rings also available.
Special End Face Seals . . .
For special sizes and extreme conditions other than those for which the C/R standard end face seal was designed, C/R will continue to develop new seals or recommend existing designs. C/R's years of sealing experience assure you of the right seal for your job.
CHICAGO RAWHIDE MANUFACTURING COMPANY
1301 Elston Avenue
Chicago 22, Illinois

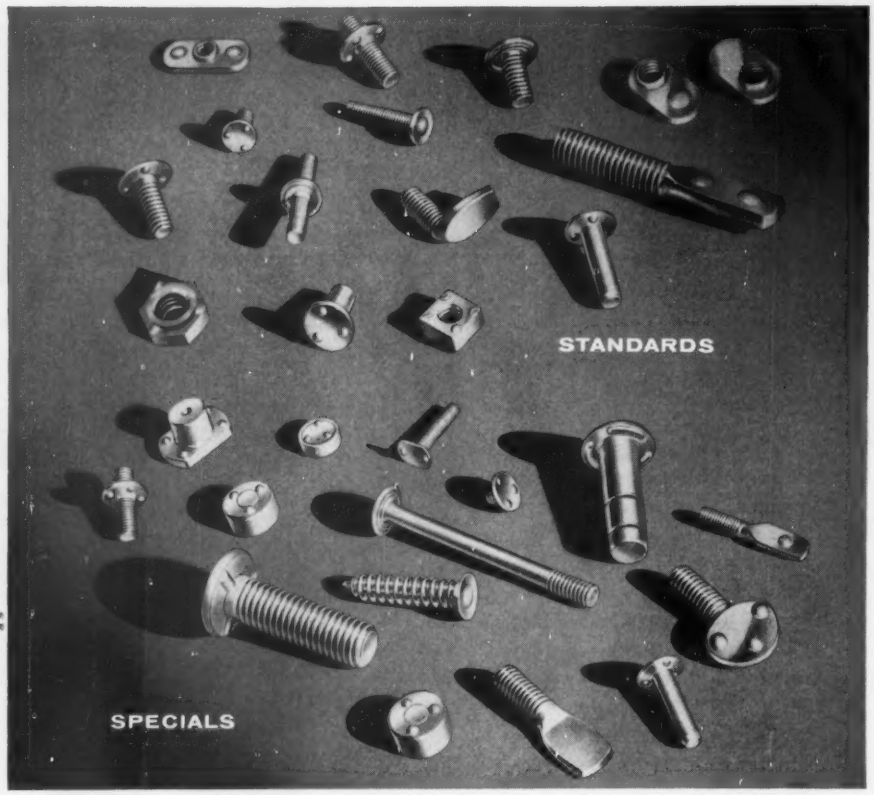
C/R

CHICAGO RAWHIDE

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears

NAT'S
quick facts
about
Fasteners...



Welding Fasteners...

the little things that make a big difference

Welding Fasteners put threads into the most unlikely places, and make light of the weightiest assembly problems.

Where hands and wrenches can't get in, for instance, or where material dimensions or contours make it next to impossible to use regular fastening methods, Weld Nuts or Weld Screws neatly side-step the difficulties . . . and make assembly simple, fast and foolproof.

We could go on and tell you more about Welding Fastener advantages . . . in improving product design and quality, increasing production efficiency, and cutting costs . . . and we'll be very glad to, if you like.

Right now, though, we'd just like to say that when you need certain standard Weld Nuts or Weld Screws, and you want to be sure they're designed right and made right . . . that's where we come in. We *know* Welding Fasteners, and we *stock* many of the most commonly used.*

We might just mention, too, that we happen to be particularly adept at developing Special Fasteners for welding. They can often be designed to do a better job and save money for you. Ask us about your applications.

*Standard types and sizes are illustrated and listed in National's booklet on Welding Fasteners. Write for your copy.

National PRODUCTS

The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

Circle 457 on Page 19

Industry's most complete line . . .

Self-Aligning

ball bearings by Link-Belt

Series 200—solid housing. For heavier applications Series 300.

Series JPS-200 provides low-cost, dependable self-alignment in a pressed-steel housing.

Series 200 and 300 split housing blocks facilitate installation.

HERE's a line of self-aligning ball bearing blocks that satisfies every application need. And look at these design features. Precision, deep-groove, single row ball bearings for smooth operation and long life. Free-rolling action and full load capacity regardless of shaft deflection and misalignment. Self-aligning seals that protect the bearing and aligning surfaces . . . prevent entry of dirt, regardless of alignment.

Simple installation too. Slip bearing on shaft and lock it securely in position with spring locking collar. Slotted bolt holes facilitate mounting on supporting structure.

For complete information on this comprehensive line, contact your nearest Link-Belt office. Ask for Catalog.

Besides pillow blocks, Link-Belt offers a complete line of standard mounted anti-friction bearing units.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,163-A

Secrets of Successful Seal Design

Fundamentals — No. 1 of A Series

SPACE — Around Sealol the bane of our existence is the job which comes to us designed in toto — "no changes allowed. Please fit your mechanical seal into this space". If there isn't space enough, the solution will usually be a compromise with performance standards sacrificed. As an example, a 1" diameter shaft will require a standard Sealol seal with a .531" operating range and a mating ring preferably .250" for a total of .781". This particular seal allows .020" for tolerance stack-up and shaft end motion. But suppose you have allowed us only .700" with a stack-up tolerance of .040"? We may be able to reduce the space required for the seal without sacrificing performance but only if the stack-up tolerance can be reduced to .020". In some cases selective assembly or shimming can produce satisfactory operating life with a bare minimum of axial space. ***Moral*** — *Send us your design before it is frozen.*

P.S. Diametrical space requirements do not bother us, but we do urge you to take into account the relative co-efficient of expansion of the stainless steel cup of our seal and the material into which you want it assembled. Sealol's Bulletin #7, Page 6, has some charts which may be helpful.

CHARACTERISTICS — In the old days, say ten years ago, you could spot an industrial seal application as distinguished from an aircraft high-performance type of application, a mile away. The former provided for rotation of the axial movable part — the latter invariably provided for these axial movable parts to be stationary in respect to the shaft. Times have changed, but designers generally favor the stationary seal where overall axial space is at a premium since it requires only 40 to 70 percent of the space of a rotary seal. Naturally, they are also much lighter. Furthermore, when shafts start turning at speeds beyond 5000 RPM, springs, pins and assorted hardware have a way of losing their functional abilities and for these situations, the stationary seal is mandatory. On the other hand, rotating seals are usually more rugged in their construction, and they are self-cleaning. They are used extensively on industrial pumps, blowers and compressors. We don't propose to be too dogmatic about the small table shown below, but it serves to delineate our present parameters for stationary and rotating seals.

MAXIMUM OPERATING CONDITIONS

	Stationary Seal	Rotating Seal
Shaft Speed	100,000 RPM — ¼" Dia.	5,000 RPM to 3" Dia.
Temp.	−425° to + 1000°F	−60° to +450°F
Pressure	2,000 psi	1,200 psi

Note: Maximum conditions indicated do not mean that all are available in a single seal.

PRESSURE — One of the most critical conditions, but one of the most inconsistent, is pressure. Many the time there has been much Sealol head-scratching over a 2 lb. pressure differential in one test rig, whereas pressures in excess of 2000 lbs. were being handled in routine fashion in an adjoining rig. We would be delighted to exchange data with you on pressure phenomena, but in the meantime, you may be interested in the following tidbits. Since operating life of a seal is a function of face load, pressure considerations can be really critical. We design to a unit face-load usually of 8 to 40 psi. depending, of course, on the spring and area involved. Hydraulic pressure of the fluid being sealed and the fluid film pressure across the seal face must also be reckoned with. Around our premises, our engineers banter back and forth a semantic generality called 'seal balance'. If you are interested, ask us for NCIH Paper "Factors in Designing for Mechanical Seal Applications to Hydraulic Equipment". Seal size has a considerable bearing on pressure capability, and as shaft diameters go up into sizes, say above 12 inches and pressures go to 500 psi, seal ring sections become quite massive to prevent distortion. Incidentally, 100 psi is about the maximum pressure we recommend for an unbalanced seal. For higher pressures, we must reckon with interface film destruction resulting from non-balanced face loads.

SHAFT SPEED — Top-flight designers are certainly stretching seal performance in many ways. Not the least is your incredible ability to cram into minute space great horsepower performance. This is meaningful to us, because the shaft speeds you now call for are exceeding, in many instances, speeds of 50,000 RPM. Of course, a 100,000 RPM — ½" shaft is probably within the capability of existing seals, but from a seal standpoint, the relative surface speed of the seal faces should not exceed about 18,000 FPM under ideal conditions. Irrespective of face materials, this seems about maximum for full contact and leakproof sealing today.

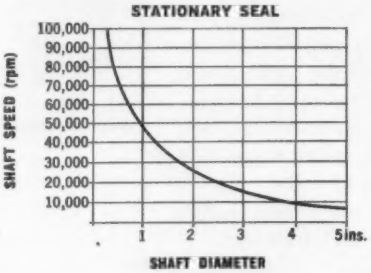
TEMPERATURE — As seal designers, our temperature goes up when you ask us for high performance beyond 450°F. ambient. This is about the usable limit for today's elastomers, such as Viton-A and Teflon. However, this too may be misleading. There are Sealol-Flexibox elastomeric packed seals doing a beautiful job in oil refineries with pump temperatures of 750°F. The secret here is, of course, controlled temperature at the seal to produce seal ambients below 450°F. However, within the last two years, Sealol's welded bellows seals are performing well at temperatures to 1000°F. Our thought for the day — if it can't be cooled to within elastomeric limits — consider the all metal welded bellows seal.

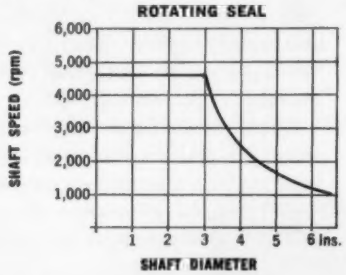
MOUNTING ARRANGEMENT — If possible, the fluid being sealed should be on the O.D. of the sealing faces. Centrifugal force of any fluid between the faces will then work in your favor to prevent seepage between the rubbing faces. Seals can function satisfactorily with fluid on the inside of the seal faces. We can both avoid long hours on the assembly line later looking for leaks if we arrange matters so that the fluid is on the outside of the face.

RUN OUT — We've heard many definitions of run out, but here is ours: The deviation of the plane of the rotating ring from a plane perpendicular to the axis of the shaft. It usually results from a lack of squareness of the rotating sealing surface to the axis of rotation. It causes a wobble of the ring and tends to bounce the seal ring away from contact at high rubbing speeds. For a 2" shaft at 20,000 RPM, run out should not exceed .0005" at the point of contact.

If these thoughts have aroused your interest, write to us with your questions, and we will be glad to elaborate.

The following tables define maximum shaft speeds under optimum conditions.





SEALOL INC.

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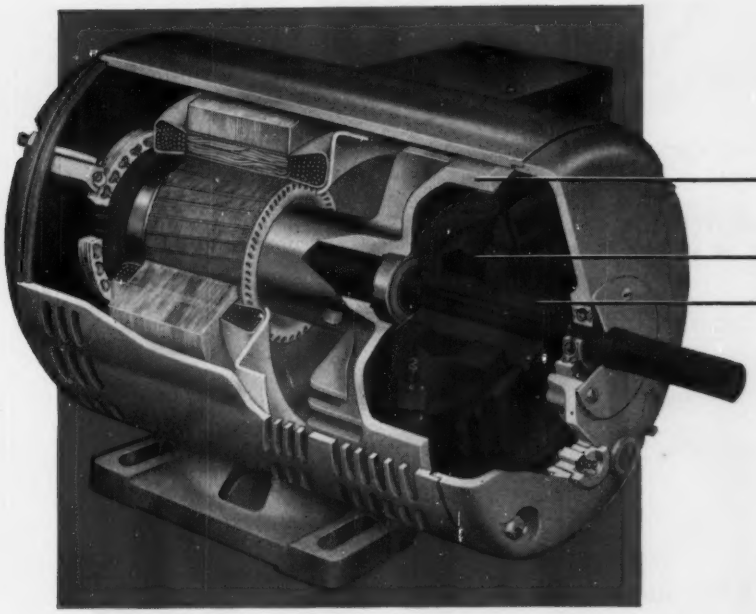


Get Stepless Adjustable Speed from AC Power

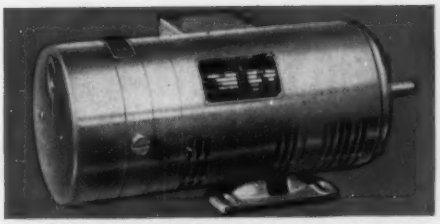
with DYNAMATIC® Fractional HP Ajusto-Spede® Drives

Wherever infinite adjustment and accurate control of speeds are required, Eaton-Dynamatic Ajusto-Spede Drives offer a simple, low-cost solution to the problem—stepless adjustment from zero to full output speed, and accurate control of any speed within the speed range.

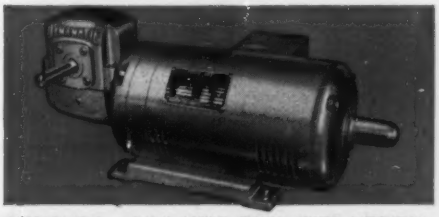
The Dynamatic Ajusto-Spede Drive is an integral combination of AC constant speed induction motor, eddy-current coupling, and plug-in type single-tube electronic control. Torque developed in the motor is transmitted to the driven member by electro-magnetic attraction; there is no mechanical contact between the driving and driven members.

Dynamatic Ajusto-Spede Drives operate on standard 115/230 volt, single phase, 60 cycle or 220/440 volt, 3 phase, 60 cycle alternating current—no special power source is required. Sizes are ¼, ½, and ¾ horsepower at 1600 RPM; ½, ¾, and 1 horsepower at 3200 RPM.

With standard, special, or remotely mounted transistorized control, Dynamatic Ajusto-Spede Drives offer many worthwhile advantages not found in other methods of speed control. Send for illustrated descriptive literature.



DYNAMATIC AJUSTO-SPEDE DRIVE WITH ELECTRICALLY OPERATED BRAKE. With the safety type friction brake, it is possible to achieve rapid deceleration and quick stop, thus providing fast cycling operation.



DYNAMATIC AJUSTO-SPEDE DRIVE WITH INTEGRAL SPEED REDUCER. Because of the variety of gear ratios available in the reducer, this compact assembly is adaptable to a wide range of slow speed applications.

EATON

DYNAMATIC DIVISION
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ORIGINATORS OF EDDY-CURRENT SPEED CONTROL EQUIPMENT

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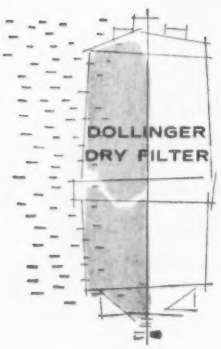


SPECIALISTS
FOR 39 YEARS

RESIST SYNTHETIC OIL TO 300° F

Filters for sump pumps and hydraulically operated equipment

DOLLINGER STAYNEW SUMP FILTERS are designed with new molded end seals of special plastic impervious to all synthetic oils, mild acids, coolants and water to 300° F. Filter medium is a mesh cloth available in either 60 or 100 screen depending on efficiency required and fluid viscosity. Exclusive radial fin design offers the greatest active filtering area in any given space. Staynew Sump Filters can be installed single or in multiple units . . . come in eight standard sizes with capacities from 5 to 100 GPM. Leading manufacturers specify Staynew Sump Filters for positive protection against dirt, sludge, rust and abrasive particles that cause expensive pump failures. Ask your local Dollinger representative for more details. Or, write for Bulletin 330-H. Dollinger Corporation, 26 Centre Park, Rochester 3, N. Y.

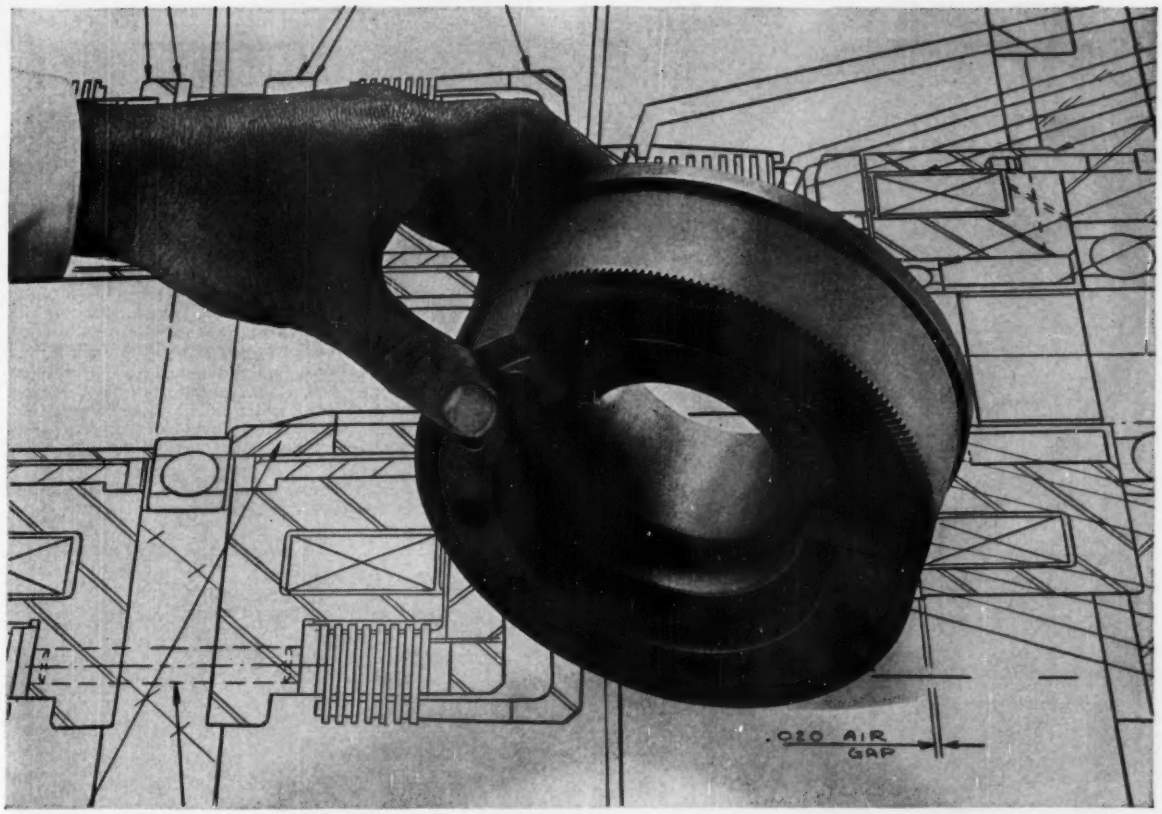
PROTECTOMOTOR

STAYNEW FILTERS

DOLLINGER

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

Circle 461 on Page 19



Bendix Elmag Tooth Clutch EZE 1200 (1200 ft.-lbs. capacity) weighs only 20 lbs. Background shows disc clutch drawing.

Bendix Electromagnetic Clutches Help You Design for Better Machine Performance

Bendix Elmag* Clutches—both Tooth and Multiple Disc types—give real help to the machine designer who wants to provide a performance "plus." These electromagnetic clutches will help your machines to outperform competitive makes . . . build your company's business by winning new customers. They have many advantages over mechanical clutches:

ELMAG CLUTCHES ARE FASTER—Engage and disengage faster; accelerate more smoothly under loads; permit faster machine operation, higher cyclic rates. CLEAN, SPACE-SAVING DESIGN—Elmag clutch units require less space than mechanical units of the same capacity. And they need no mechanical linkage. EASE OF CONTROL—Clutching control is accomplished remotely by a set of electrical contacts.

*REG. U.S. PAT. OFF.

NEW ELMAG TOOTH CLUTCH—for positive, high torque transmission • Absolutely no idle torque • Engagement at relative speed possible • Disengagement possible under full load while running at maximum RPM • Bolt-on design (simple mounting adapter) • Wet or dry applications • Available from stock in torque capacities of 40 to 4,000 ft.-lbs.

ELMAG MULTIPLE DISC CLUTCH—Provides precise control and quick response in high-frequency operations. Ideal for step-by-step control of large masses. Disc stack is magnetically isolated.

ELMAG CLUTCHES ARE A RECENT BENDIX ACQUISITION FROM McCAULEY INDUSTRIAL CORPORATION

For full details, write:

Bendix-Elmira
ECLIPSE MACHINE DIVISION
Elmira, New York

Bendix
AVIATION CORPORATION

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BEARING TIPS
by McGill

McGILL sealed GUIDEROL® bearings preserve high capacity performance of needle bearing applications

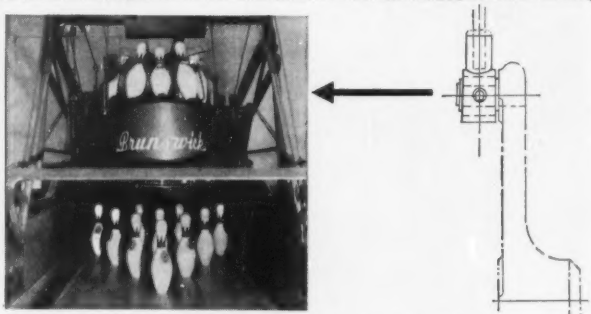
Lip type contact seals built into GUIDEROL bearings insure longer life for their high capacity performance in limited radial space. It's simpler and less costly to apply these sealed bearings than build in auxiliary seals that increase bearing width and housing requirements.

GUIDEROL bearings, including the sealed series, are precision built and combine the inherent high capacity of full complement roller bearings with the control of center guided rollers. This recommends the bearing for applications too heavily loaded for retainer type bearings, but where shaft deflection and misalignment prevents the use of ordinary full type roller bearings.

Seals keep contamination out and lubrication in. This assures trouble free performance where maintenance is costly or impractical.

Sealed GUIDEROL minimizes torque in ACF "Piggy-Back" trailer hitch

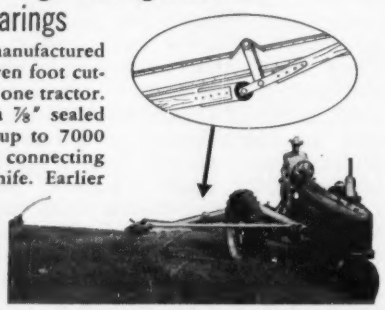
McGILL Sealed GUIDEROL bearings meet the requirements of a high capacity needle bearing for small radial space, having adequate seals to prevent entry of foreign materials and loss of lubricant in this exposed application. The bearings, in the elevating arms, minimize the amount of torque required to elevate the trailer hitch and jack the trailer off the car floor. The hitch, manufactured by American Car and Foundry Division of ACF Industries Incorporated, is a tiedown and cushioning unit for semi-truck trailers on flat car (Piggy-back) use. Although speeds are low, loads are as high as 20,000 lbs. per bearing. Grease relubrication when desired is applied through the shaft to the inner race of the bearing.



"Trouble-free" performance of automatic pinsetter called for Sealed GUIDEROL bearings

Prelubricated and Sealed GUIDEROL bearings are used in two applications in BRUNSWICK AUTOMATIC PINSETTERS; on the Rake Crank Lever Assembly and on the Jogger Arm Assembly. The photo shows the location of the sealed GUIDEROL Rake Crank Lever application in the "mechanical brain" of the machine. The sealed GUIDEROL bearings help keep the "brain" highly efficient, with a minimum of maintenance. In the Rake Crank they are not relubricated and operate indefinitely on retained lubricant. Effective seals keep out dirt and foreign matter.

New mower design takes high cutting loads on Sealed GUIDEROL bearings



These unusual field mowers manufactured by Kosch Mfg. Co. use two seven foot cutting bars for a 14 foot cut with one tractor. The second bar depends on a ⅞" sealed GUIDEROL bearing to carry up to 7000 pound loads produced in the connecting drive for the reciprocating knife. Earlier sleeve and lower quality needle bearings were discarded for sealed GUIDEROL bearings that have prevented costly field breakdowns.

engineered electrical products

McGILL®

precision needle roller bearings

SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 463 on Page 19

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Precision-made, high-volume screw machine parts cost less in aluminum

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ALCOA ALUMINUM

SCREW MACHINE STOCK

Circle 464 on Page 19

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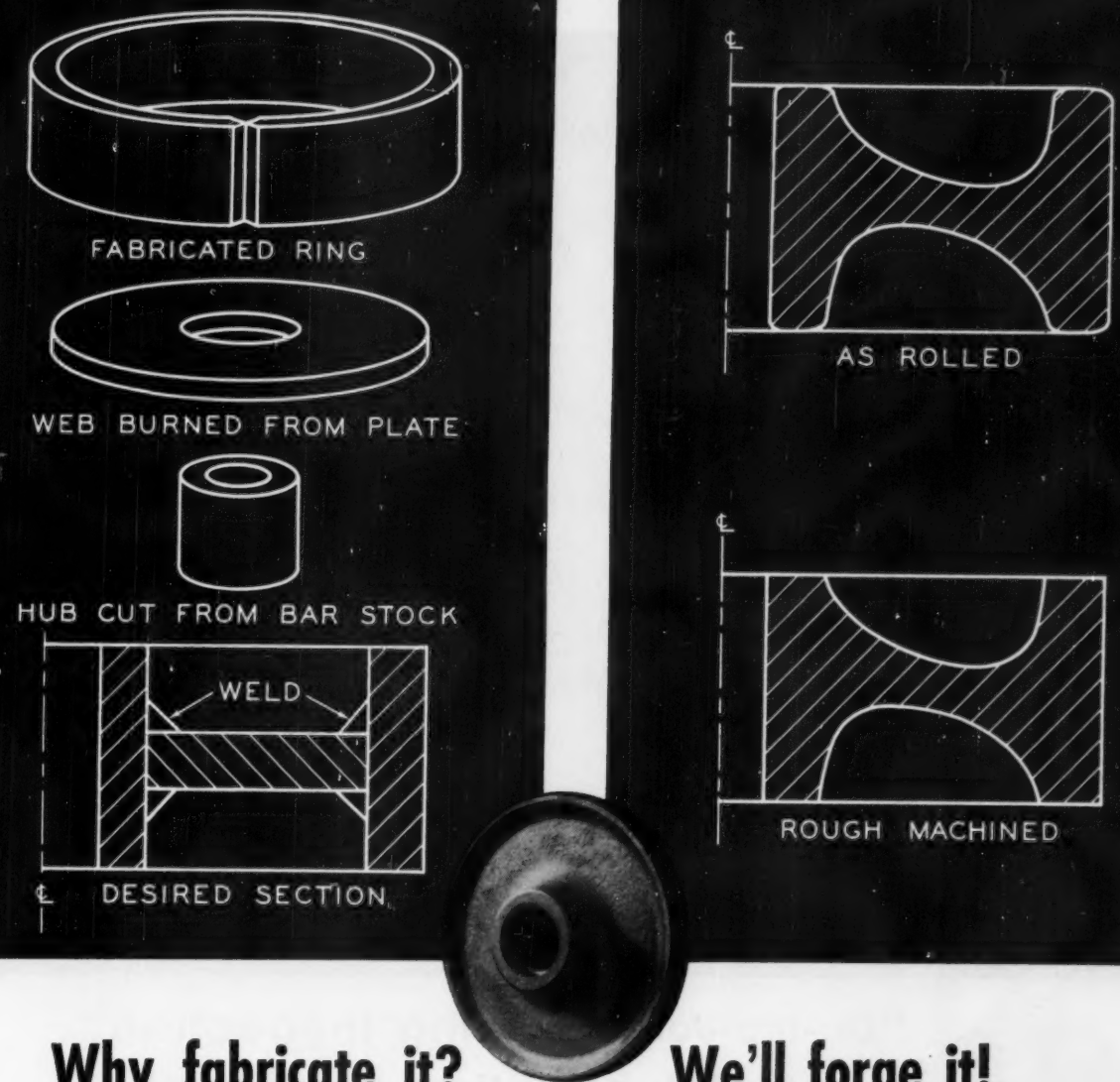
BALL AND ROLLER *bearings*

Circle 465 on Page 19



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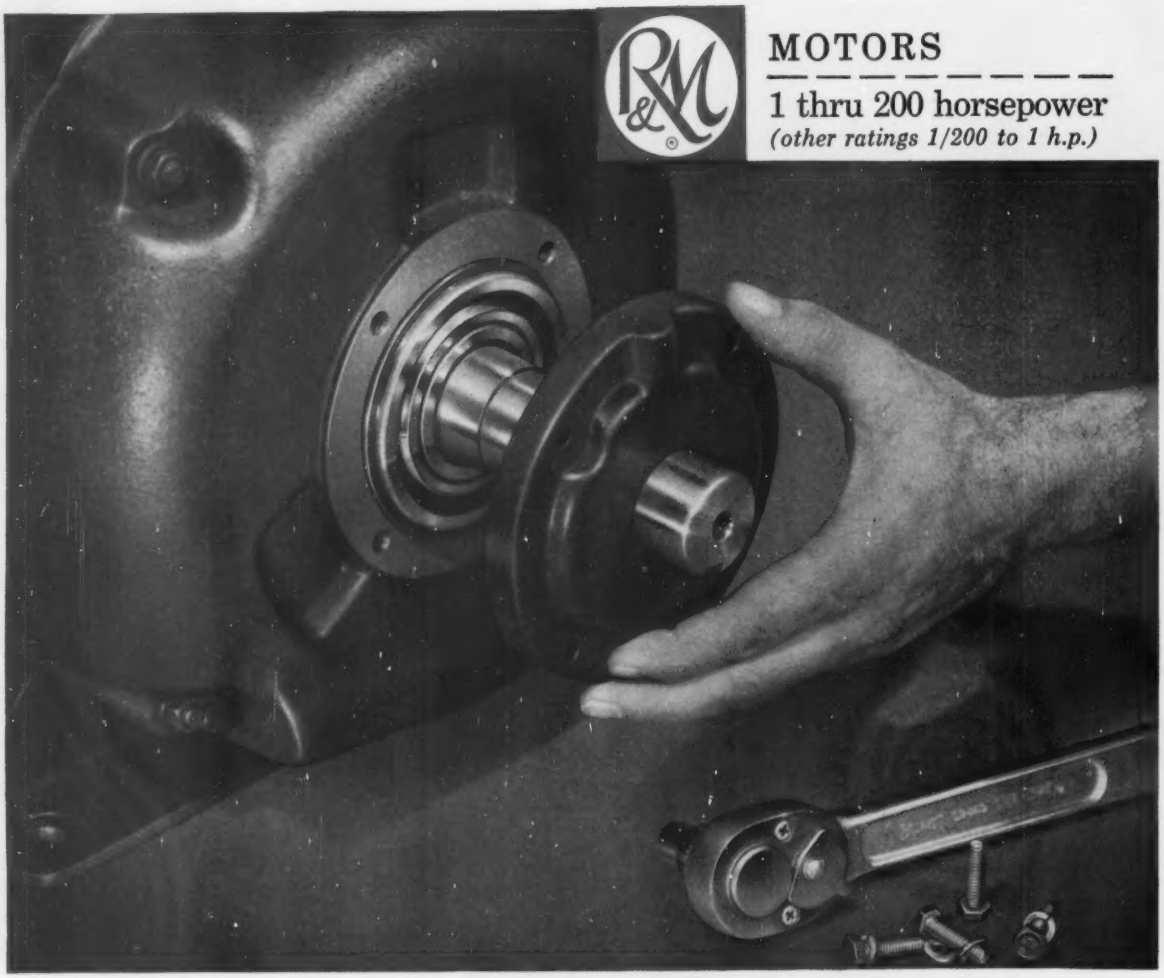

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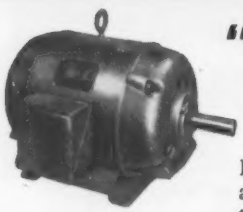

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Easily removable bearing caps are only one of R&M's many desirable design features. Double width bearing races have extra-large grease capacity . . . Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . end heads offer full-height protection . . . dual-sweep ventilation assures efficient cooling. For details, write today for Bulletin 520 MD

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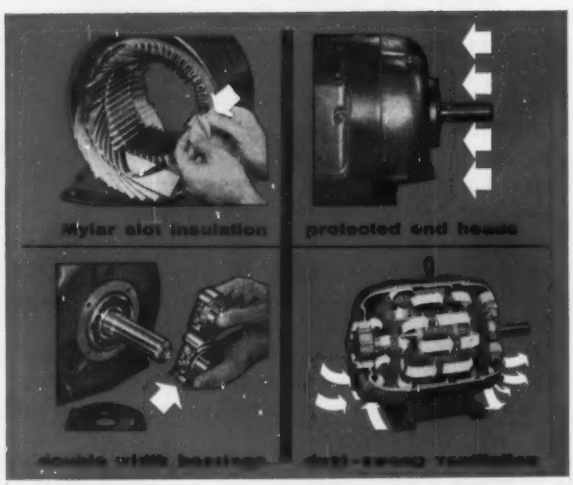

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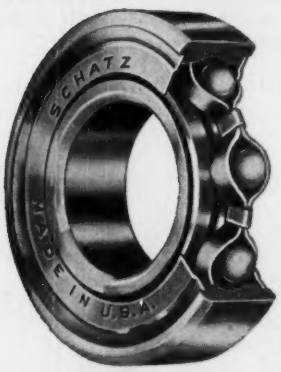
Schatz makes the most varied line of Ball Bearings to fit your needs



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23 sizes from 3/16" to 1"—6 types in each size + specials

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UNGROUND BALL BEARINGS "TYPE A"—Every standard type—radial, thrust and radial thrust.

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1033 sizes to match your Bearing Application Needs

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We'll fit these bearings—or special types and sizes to your special needs. Just fill in your application problem below—attach to your letterhead and mail.

THE SCHATZ MANUFACTURING COMPANY, Poughkeepsie, N. Y.

Here's our bearing problem. What do you suggest?

APPLICATION_____

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SIZE_____

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NEW SPICER TWO-PLATE CLUTCH LINE DESIGNED FOR HIGH SPEED, HIGH TORQUE ENGINES!

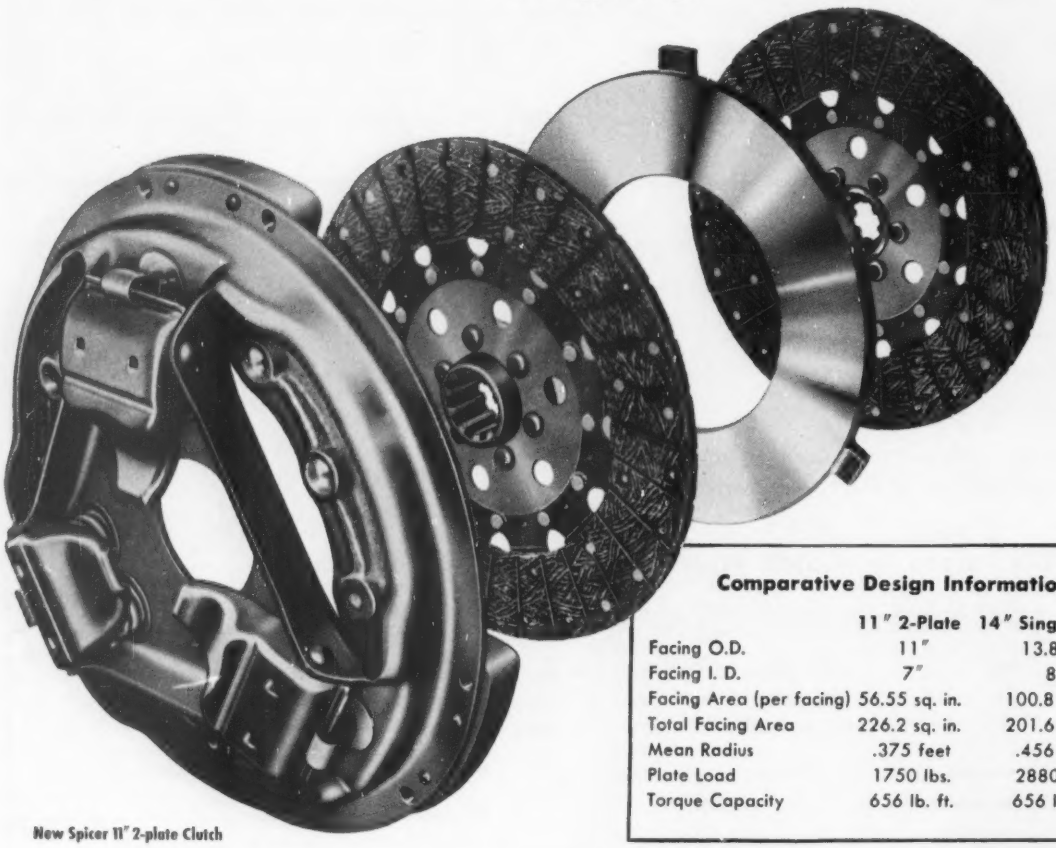
Spicer *heavy-duty* 13", 14" and 15½" 2-plate clutches have for years been taming high torque loads on the most powerful automotive power plants built. Now this pioneering know-how has been used to develop a *complete range* of 2-plate clutches from 8½" to 12", in addition to the already established 13", 14", and 15½" units.

The new Spicer 11" 2-plate clutch, now in production, is designed for vehicles with GVW's up to 60,000 pounds, and engines in the torque range from 300-400 pounds/feet.

The new range of Spicer 2-plate clutches will reduce inertia, lower release effort by 40%. Built-in parallelism guarantees uniform pressure across entire surface of pressure plate, regardless of wear or adjustment. Reduced peripheral speeds offer greater resistance to burst.

The new clutches will be smaller, lighter in weight, yet have greater facing area for increased clutching efficiency.

Spicer two-plate clutches are available in damper, rigid or cushion disc design with riveted, bonded or ceramic type facings.



New Spicer 11" 2-plate Clutch

Comparative Design Information

	11" 2-Plate	14" Single Plate
Facing O.D.	11"	13.875"
Facing I. D.	7"	8"
Facing Area (per facing)	56.55 sq. in.	100.8 sq. in.
Total Facing Area	226.2 sq. in.	201.6 sq. in.
Mean Radius	.375 feet	.456 feet
Plate Load	1750 lbs.	2880 lbs.
Torque Capacity	656 lb. ft.	656 lb. ft.

Write today for complete information on the new line of Spicer 2-plate clutches.

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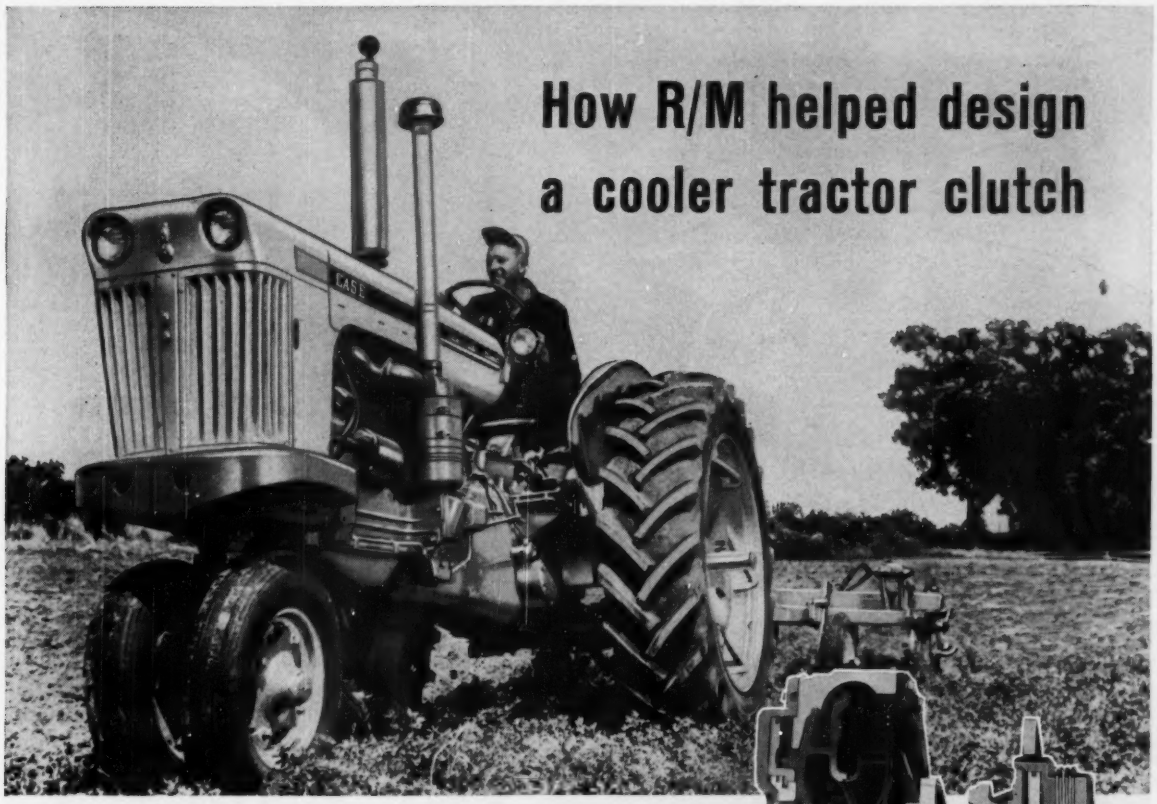
Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters Powr-Lok Differentials • Gear Boxes • Forgings Axles • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

How R/M helped design a cooler tractor clutch



Case-o-matic Drive torque-converters on J. I. Case tractors use waffle-grooved R/M sintered bronze friction material in master clutch.

Improved heat dissipation in a forced-cooled clutch resulted from close co-operation between engineers of Twin Disc Clutch Co., Racine, Wis., and Raybestos-Manhattan.

Waffle grooving

As a manufacturer of all types of clutches, Twin Disc has wide experience in the useful application of friction. This knowledge, combined with R/M's friction know-how and laboratory and research facilities, produced a clutch plate of sintered bronze with waffle-type grooving, which improves cooling and lubrication.

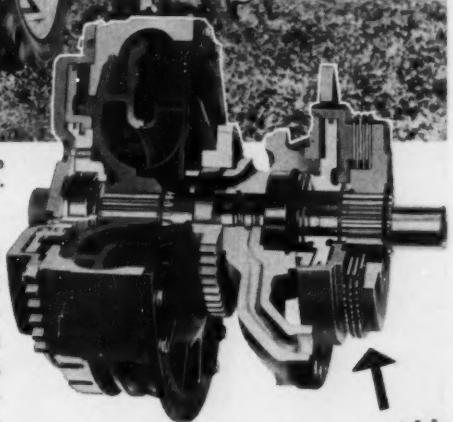
Three of these friction plates are used in master clutches of Case-o-matic Drive torque-converter transmissions manufactured by Twin Disc for J. I. Case farm tractors.

For over 20 years, R/M has worked with every kind of friction material for thousands of specialized applications. Only R/M manufactures all types of friction materials. For this reason you can be sure you are receiving *sound, unbiased advice from R/M on the material best suited to your application.*

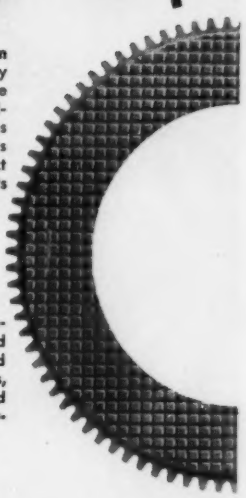
Outstanding service

Why not take advantage of R/M's broad experience and outstanding service—an R/M sales engineer can be at your desk within 24 hours.

Want helpful engineering data on friction materials? Send now for R/M Bulletin 501—no obligation.



Unique clutch design revealed in cutaway of Case-o-matic Drive transmission. Balanced-piston system eliminates clutch release springs and provides compact design. Arrow points to clutch plates.



Waffle grooves improve cooling and lubrication. Sintered bronze friction facings, .022 in. thick, bonded to a 14 gage copper-plated base plate.

RM

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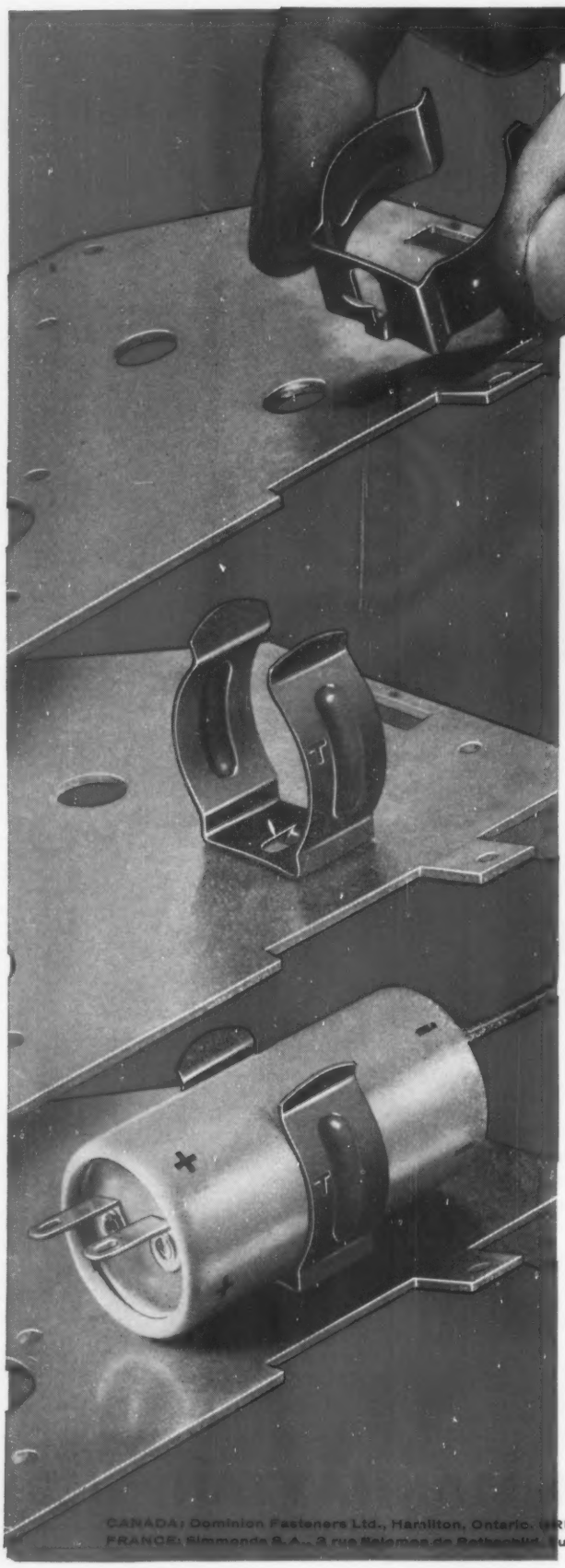

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SPEED CLIPS can be provided in various sizes to hold capacitors and other cylindrical parts from $\frac{3}{8}$" to $1\frac{1}{2}$" in diameter and to fit a wide range of panel thicknesses.

Samples and prices of these SPEED NUT brand fasteners are available from your Tinnerman sales engineer. If he isn't listed in your Yellow Pages, write to:

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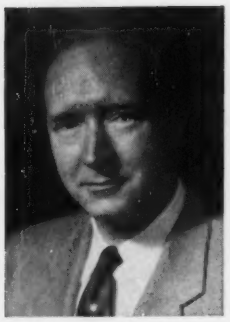
DESIGN
May 26, 1960



Tempered by Experience

PRINCIPAL difference between alloy and plain steels, we are told, is the ability to respond to heat treatment. In the annealed state the differences are much less pronounced; tempering brings them out.

In pondering our current series of news articles on engineering technicians, we wondered whether a similar criterion might also apply to technicians versus engineers.

Ingredients of an engineer—such as education, intellect, and personal characteristics — enable him to respond when the heat's on. His function is to plan, to create, to originate, to organize.

The technician can carry a load, but is not normally expected to make tough decisions. He is the doer, the craftsman, the specialist, the detailer.

Indications are that many employers today are hiring engineering graduates to do technician's work. One reason may be that there seems to be a shortage of technicians, and engineers are not yet too expensive. Another is that some engineers, so-called, don't possess all the ingredients of a top-flight engineer. They may be excellent doers, but not the stuff of which planners are made.

But human abilities come in all grades, just as steels do. Of the multitude of engineering graduates performing routine tasks, how many have the potential to become high-level operators? Only the proper "heat treatment" will tell.

To develop strength and toughness requires tempering. Strong, tough engineers can be developed only if they are given challenging opportunities and an incentive to rise to their opportunities.

How long is it, Mr. Engineering Manager, since you systematically tested the "hardenability" of your people?

Colin Carmichael

EDITOR

Microfilm has earned a good name as a means to preserve engineering drawings. Today, however, microfilm bids for a bigger job in daily use as a direct aid to designers. From punched cards which carry single frames of film, new machines and procedures quickly provide working-size enlargements, singly or in quantity.

American Machine and Foundry Co. has recently studied various systems for relatively large-volume needs. Here is that company's analysis of . . .

Active Microfilm Systems

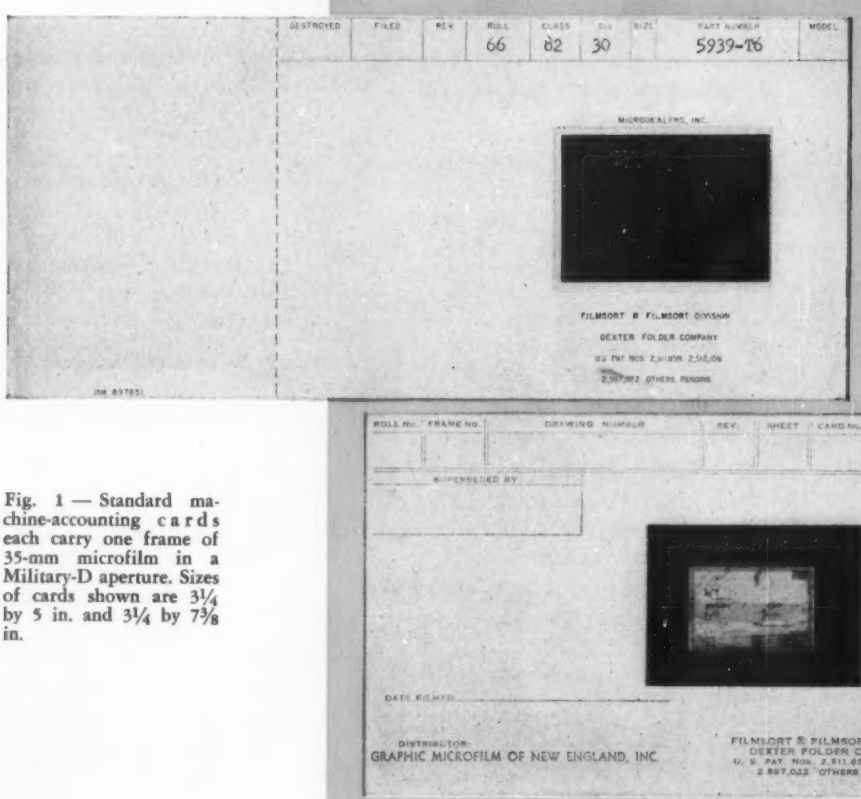


Fig. 1 — Standard machine-accounting cards each carry one frame of 35-mm microfilm in a Military-D aperture. Sizes of cards shown are 3¼ by 5 in. and 3¼ by 7⅜ in.

UNTIL a few years ago, security and disaster were nearly the only reasons for microfilming engineering drawings. More recently, engineering applications have been extended and enlarged by the development of new equipment, systems, and techniques. *Passive* microfilm is the security type, while *active* microfilm is used in the day-to-day procedures of an engineering department. This article concerns *active* systems.

Film, Equipment, and Accessories: Comparatively, microfilm is durable and inexpensive. The U. S. National Bureau of Standards has stated that microfilm, properly processed, will last at least 250 years. With the average original drawing costing between $45 and $160—and its life not nearly 250 years—microfilming at pennies per drawing is a bargain. Active use of microfilm in a well-organized system can virtually retire the engineering tracing after its preparation.

Currently, microfilm is used in three widths: 16, 35, and 70 mm. The 16-mm size is generally used for filming 8½ by 11-in. records, while 35 and 70-mm sizes are used universally for filming engineering drawings. Commercially available equipment is capable of filming, on one 35-mm frame, a complete E-size drawing (34 by 44 in.), and enlarging this film back to original size without distortion. Drawings larger than E size are filmed in sections.

It is practical to plan integrated, active, microfilm systems due to the development of new equipment such as projection-type printing machines, and supporting units. However, in order to use microfilm as an integral part of the day-to-day operation of an engineering department, it is necessary to have the actual film in other than roll form. Use of roll film as a reference medium is awkward and requires roll-film adapters on viewers. Engineers and draftsmen generally resist use of roll film. Furthermore, most roll-film adapters tend to scratch the film. To circumvent this hazard, single frames of microfilm are mounted in aperture cards. The cards are easy to use and file without scratching the film.

Aperture cards are supplied in various forms and sizes, but the two sizes that are used the most are 3 by 5 in. and the tabulating card size 3¼ by 7⅜ in., Fig. 1. The advanced systems shown in Fig. 2 through 4 are built around the tabulating card containing the Military-D aperture for insertion of 35-mm frames. Every Military-D card approved for government use has the aperture in one specified location. This location is rapidly becoming a standard. Printing machines, for making prints automatically from microfilm in aperture cards, are designed to take only cards with the Military-D aperture. Such cards can be preprinted for ease of inserting typed filing data on top edge, and punched information, other than drawing number data, can be inserted. Cards with these data can be used in electronic accounting machines (EAM) to provide bills of materials, drawing lists, and similar data.

Success of systems depends upon getting clear, legible copies of drawings in the volume and speed desired. Copy machines based on various processes have been developed to meet these needs.

For the purpose of the analyses presented here, machines based upon the electrostatic printing principle are used. Specifically, the xerographic process (Haloid-Xerox) is the basis of two machines used alternatively in this study.

One machine, identified here as a single copy unit, produces enlargements at the ratio of 14.5 to 1 from 35 mm frames mounted in cards containing the Military-D aperture.

The second machine is a continuous printer designed to produce 20 linear feet of prints per minute, from 16 or 35-mm negative or positive film in rolls, or from 35-mm frames mounted in Military-D aperture cards. Except for loading and unloading stacks of cards, card handling is automatic. The machine prints on roll stock and automatically cuts copies to uniform length.

At the present time, only a few of the larger companies have active microfilm systems in operation. These are geared for upward of 30,000 new drawings and changes in 50,000 existing drawings per year. Necessary capital investment for an active system is proportional to activity and volume.

Basic System: A basic active system might operate and consist of the equipment shown in Fig. 2. This system requires a minimum outlay for capital equipment. It would provide: Roll film for security purposes, film in Military-D aperture tab cards, hard copy prints, and reference viewing facility. In

this basic system, cards are not keypunched, and drawing title data are handwritten on each card.

Basic Benefits: The first benefit is a saving in space. In effect, vast areas of cabinets for storing drawings and prints are condensed into a very small space. Only one standard print machine is required for special rush prints from tracings. Space requirements for an active microfilm system are much less, to copy a large volume of drawings, than any present system. Additional space is saved when original tracings are purposely destroyed. Present-day quality of microfilm images permits this disposition.

Operating costs of the reproduction department in an active microfilm system are lower than in other systems. The cost of aperture cards and electrostatic print machine paper is less than blue or whiteprint paper. For example, a full-size print of a 24 by 30-in. drawing from a standard reproduction machine costs between 24 and 30 cents while the same copy from the electrostatic printer costs about 15 cents. Since larger drawings on film are printed half their original size in the electrostatic printer, savings can be realized in the folding, packaging, and mailing of smaller prints.

Many file-maintenance operations are eliminated or simplified and better, faster service is supplied by fewer people.

A security file and microfilm copies of obsolete drawings can be maintained economically.

By using aperture cards, draftsmen and engineers need not handle bulky tracings or prints. Information on cards can be read conveniently in an inexpensive viewer. This is especially advantageous for an engineer, remote from the engineering department, who is required to answer questions, by telephone, on jobs involving hundreds of drawings.

Basic Cost: Although there has been no published information regarding operation costs or savings, the prices of equipment are available, Table 1. Estimated cost for filming a thousand drawings, indexing by key punch, mounting two sets of film in aperture cards, and filing one of these sets (the other set would be sent to a security vault) would approximate $200.

Estimated cost for operating personnel for the basic system is shown in Table 2. The estimate is based on the assumption that the engineering facility would generate no more than 200 drawings and documents per day. One operator would perform all functions enclosed by the dotted line in Fig. 2. These functions would be carried out on a 4 to 12-p.m. shift, so filming completed one day could be used the following day.

Cost of aperture cards is $37.50 per thousand when bought in lots of 100,000, film is approximately $3.50 per 100-ft roll, and paper for the electrostatic printer costs about 1 cent per square foot. Duplicate aperture cards for duplicating the master deck are 5 cents each.

This basic system would be considered adequate

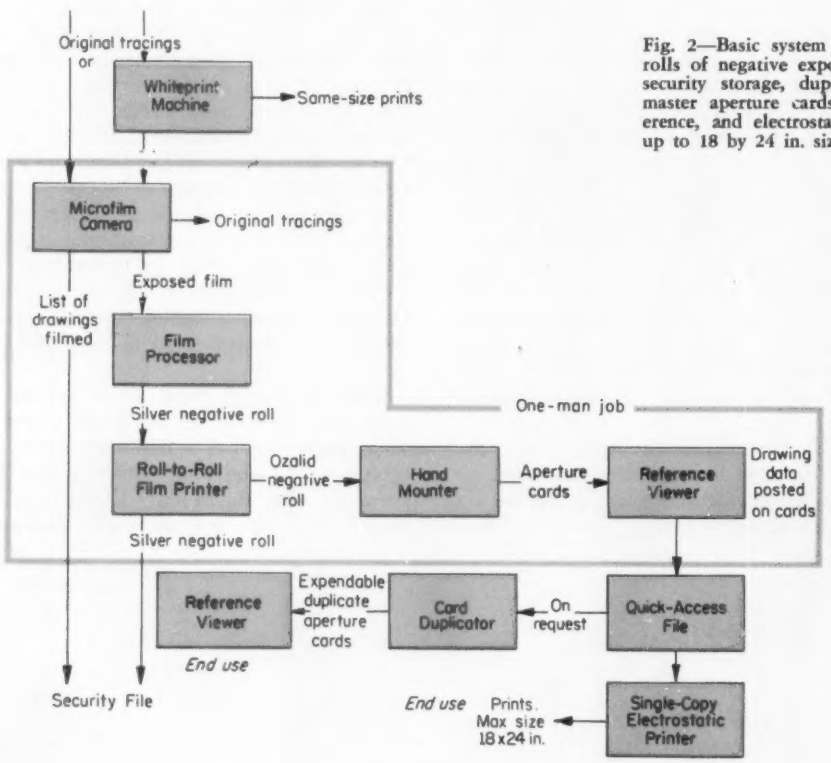


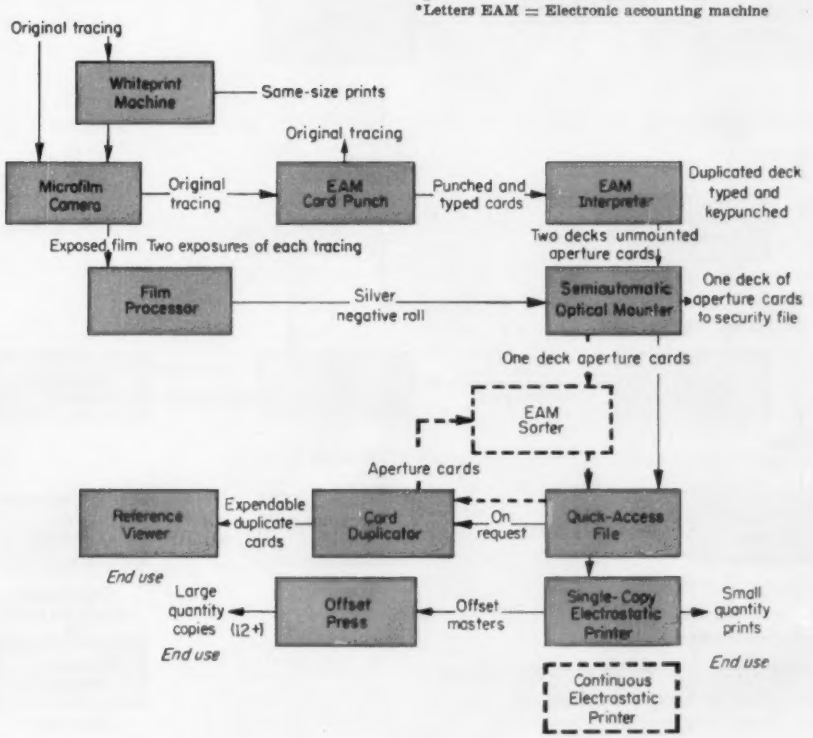
Fig. 2—Basic system generates rolls of negative exposures for security storage, duplicates of master aperture cards for reference, and electrostatic prints up to 18 by 24 in. size.

Table 1—Equipment Costs in Microfilm Systems

Equipment — Type	Rental* ($ per mo.)	Cost* ($)	(a) Basic System Fig. 2	(b) Modified Basic Fig. 3	(c) — High Volume of: — Drawings Fig. 3	(d) — High Volume of: — Copies Fig. 4
Microfilm camera		5,150	●	●	●	●
Film processor		2,725	●	●	●	●
Viewer, for film inspection		475	●	●	●	●
Roll-to-roll film printer		1,800	●			●
Quality control instruments		200	●	●	●	●
Hand film mounter		620	●			●
Semiautomatic optical mounter		4,750		●	●	
Reference viewer		150	●			
Quick access file		495	●	●	●	●
Card duplicator		750	●	●	●	●
EAM Card punch	60			●	●	●
EAM Interpreter	90			●	●	
EAM Sorter	50				●	
Electrostatic printer,						
Single-copy	200	(10,000)	●	●		
Continuous	3,200				●	
Electrostatic camera	400	(25,000)				●
Offset press		3,750		Optional	Optional	●
Total capital cost			12,365	14,545	14,545	15,965
Total rent, per month			200	350	3,400	460

Fig. 3—Medium volume system without EAM sorter and continuous electrostatic printer provides duplicate aperture cards for a security file. In card form, security file can be maintained as current as daily reference sets. High-volume system is created by addition of EAM sorter and substitution of continuous electrostatic printer for the single-copy machine. Latter arrangement delivers same quantity of prints—1 to 400—from each aperture card inserted at one time.

*Letters EAM = Electronic accounting machine



for a medium volume operation—up to 2-million sq ft of reproductions annually. Total equipment and rental costs—not necessarily the lowest—are listed in column *a*, Table 1. Note that a reference viewer shown in Fig. 1, for viewing duplicate cards, is not included in basic cost. It may be necessary to have several of these viewers for reference purposes.

Basic System, Modified: The system shown in Fig. 3 is similar to that shown in Fig. 2 except for the addition of a card punch machine, substitution of a semiautomatic card mounter for a hand mounter, and deletion of a roll-to-roll film printer.

A punched card would be prepared for each drawing. Since the card punch machine also types, as required, the data punched, necessary filing information can be shown on the top edge of the card. Other pertinent data can be punched into cards at this station for possible use by purchasing, parts, receiving, or inspection departments.

Since most companies' security film at present is filed in roll form, an explanation is in order as to why aperture cards are shown as the security file in Fig. 3. In case of a disaster, a major problem would be encountered in sorting to restore the most important drawings first. For efficient utilization of enlarging equipment, drawings should be sorted according to drawing size, and only the latest drawing revision should be reproduced. This sorting can be handled expeditiously with film in aperture cards.

The value of microfilm for space saving is realized to the fullest when the original tracings are purposely destroyed. A drawing destruction program can operate much more effectively if the microfilm is in aperture cards instead of roll form. A series of drawings, even a modern series, contains many inactive drawings which can be destroyed. Spot drawing destruction year after year, with co-ordinated microfilming will soon render the roll film file almost useless. However, such spot destruction is conveniently done if the security file consists of aperture cards permitting the latest revision to be maintained on an individual frame basis. The master quick-access file would only maintain an aperture card on the latest drawing revision. An important advantage in the use of aperture cards for security purposes is that it eliminates the necessity for a listing of the drawings contained in each roll of film.

The offset press, shown dotted on Fig. 3, is in-

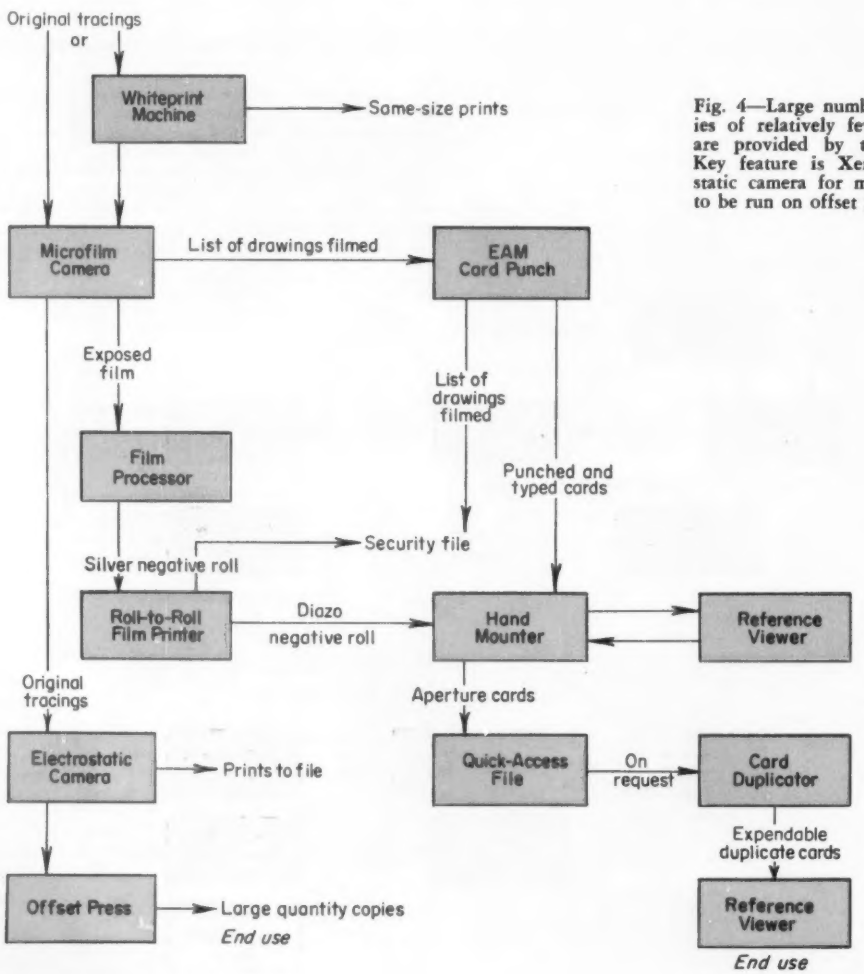


Fig. 4—Large numbers of copies of relatively few drawings are provided by this system. Key feature is Xerox electrostatic camera for making mats to be run on offset press.

cluded for preparation of drawing copies when a large distribution of drawings is necessary. When a drawing system requires distribution of more than 12 copies, or copies of each drawing developed are stockpiled, big savings can be realized by preparing offset mats on the electrostatic machine instead of hard copy prints. When mats are run on the offset press, copies are made much faster and at a fraction of the cost of standard white/blue prints or hard prints from the electrostatic machine.

The system in Fig. 3 is adequate for a medium-volume operation—up to 2 million sq ft of prints annually.

High-Volume of Drawings System: Addition of an automatic sorter, and substitution of a continuous electrostatic printer in place of the single-copy printer make the system in Fig. 3 a high-volume operation —4 to 5 million sq ft of reproductions annually. The sorter rapidly picks out cards by drawing number, by project, by job, or by any other coding included on the punched cards. The EAM equipment enables the system to process a large number of original drawings. Cost is itemized in Fig. 2.

An additional labor-saving device that can be used with the electrostatic print machine is an automatic folder. This is not shown on the flow chart because use depends on volume of prints to be folded.

High-Volume of Copies System: The distinguishing feature of the system in Fig. 4 is to provide large numbers of copies from each drawing processed.

After microfilming all tracings, sizes A, B, C, and D are sent to the electrostatic camera where an offset master, largest size 12 by 18 in., would be prepared for making multiple copies on the offset press. All *rush* prints, regardless of size, and all prints from drawings sizes E (34 by 44 in.) and larger are made on the whiteprint machine.

This system has other advantages. Microfilm frames of size D originals can be enlarged to translucent paper intermediates one-half the size of the originals with corresponding savings of paper.

An automatic method of making half-size paper intermediates is available. A Peerless Photo Products camera reduces original drawing tracings on a continuous basis to any of six reduction settings.

The system in Fig. 4 is particularly adapted to a company having many standard drawings, and where a large renewal-parts department requires stock prints of drawings. An extension of this system could place a deck of punched aperture cards in a renewal-parts department for quick reference.

Systems in Fig. 2 and 3 operate under normal light conditions. However, with the system of Fig. 4, it is necessary that the exposure end of the camera be located in a darkroom. The plate charger and developer also require a darkroom.

Considerations: Despite savings and convenience, installation of an active microfilm system is not without its problems. Foremost, perhaps, is resistance by draftsmen and engineers to the use of film instead of a blue or whiteprint. To provide necessary quality of reproduction, some drawing methods must be reviewed or changed. Draftsmen must be trained to think in terms of microfilming. Drawing standards must contain information on pencil hardness, work surfaces, line widths, height of lettering, and proper delineation of fractions. In this regard, many simplified drafting practices are suited to drawing for microfilming.

Systems presented here work very efficiently when serving an engineering department located in one building or in one central area. Rapid service can be expected. However, if an engineering department is located in one town and several components located in other towns, much of the effectiveness of microfilm is lost.

Use of microfilm, because of its utility and savings, has prompted the United States Government to accept microfilm instead of tracings where venders' drawings are required on many contracts. The Defense Department Security Manual does not prohibit the use of classified microfilm as a reference medium in an engineering department. Of course, classified microfilm must be afforded the same security measures now given to classified tracings and prints.

Many questions must be answered prior to installation of a system. A detailed study must be made of current drawing procedures. One important study is total drawing output per day, total volume of prints presently being made, and what percentage of these prints are being made for reference purposes only. Other detailed studies must determine print output required of the new system. Will hard prints direct from the electrostatic machine be most economical, or will it be more economical to prepare offset mats and run the required copies on the offset printing machine?

An excellent guide is available for assistance in surveying microfilming equipments. *Guide to Microreproduction Equipment,* published by the National Microfilm Association, P. O. Box 386, Annapolis, Md., contains sections on available cameras, viewers, processors, printers, enlargers, and film now available.

ACKNOWLEDGEMENT

Data presented in this article were developed by Thomas R. Sainsbury while employed by the Engineering Services Laboratory, American Machine and Foundry Co.

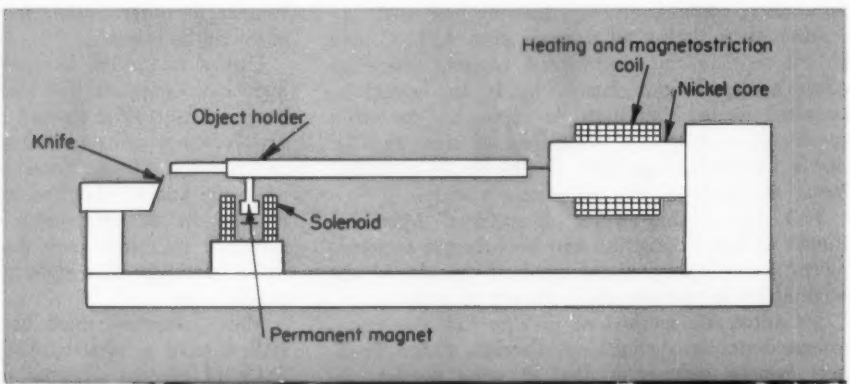
•Letters EAM = Electronic accounting machine

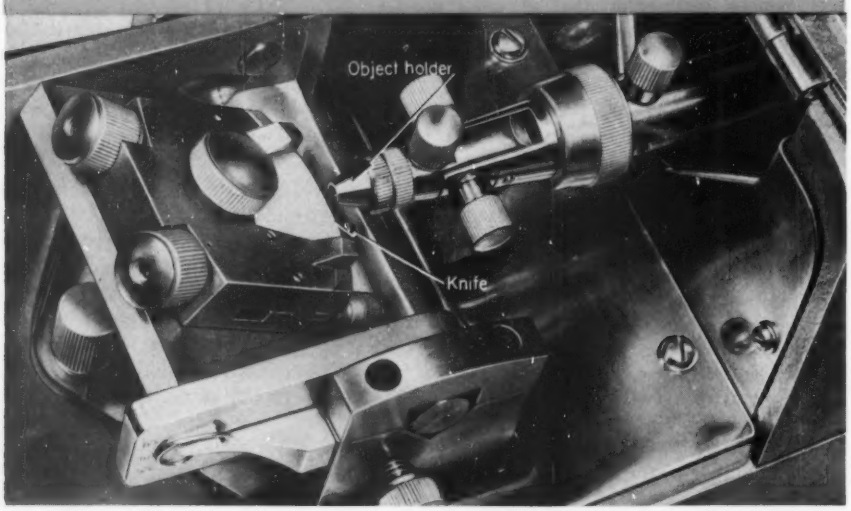
Table 2—Labor Cost in Microfilm Systems

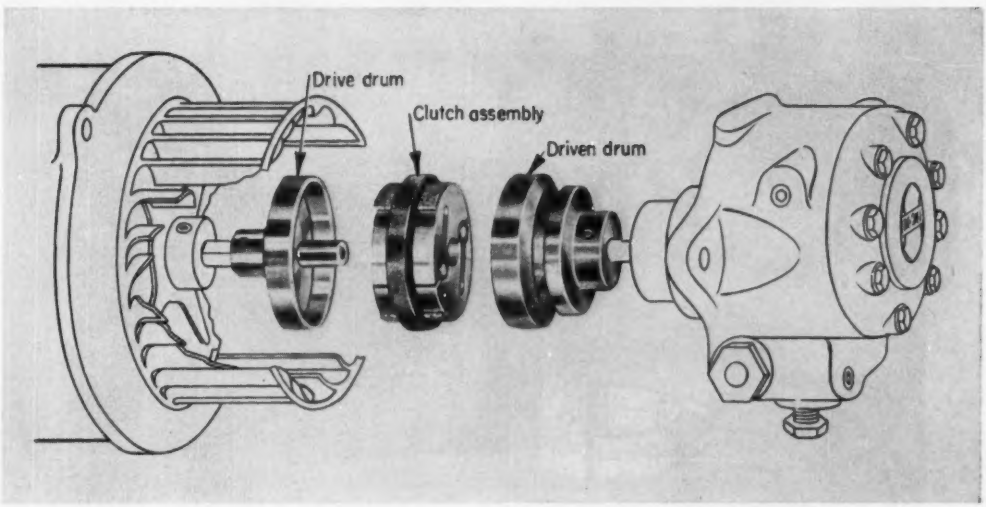
Personnel one of each	Cost ($ per yr)
Multiple-function operator (Fig. 2)	6,000
Whiteprint machine operator, and other duties	3,900
File clerk for master card file	3,400
Electrostatic printer operator	5,000
Clerk for print folding, mailing, and general duty	3,400
Total	21,700

scanning the field for *ideas*

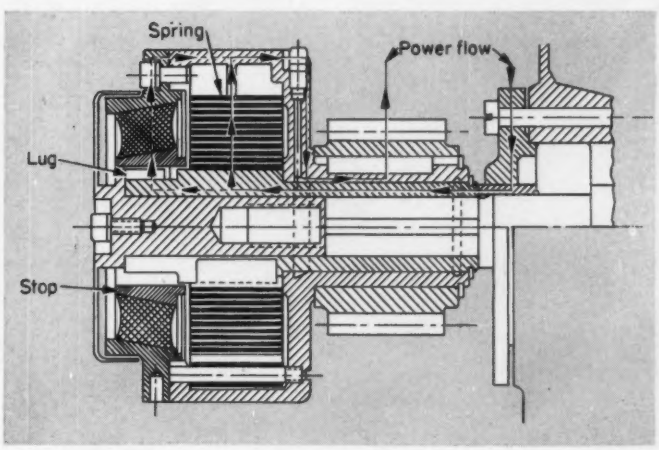
Expansion feed provides movement increments as small as 0.009 microinch. Magnetostrictive effect of feed coil withdraws object holder to provide clearance during vertical stroke. Electrical heating of feed coil expands nickel core to produce horizontal feed. Principle employed in ultramicrotome developed by Elektro Spezial GmbH, Hamburg, Germany.





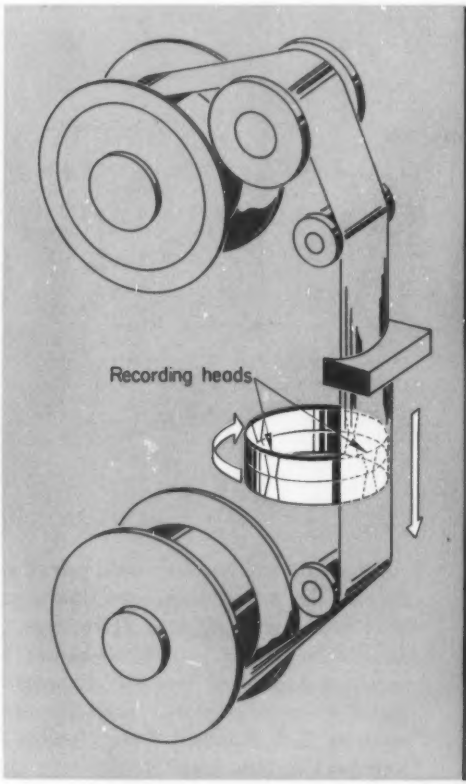


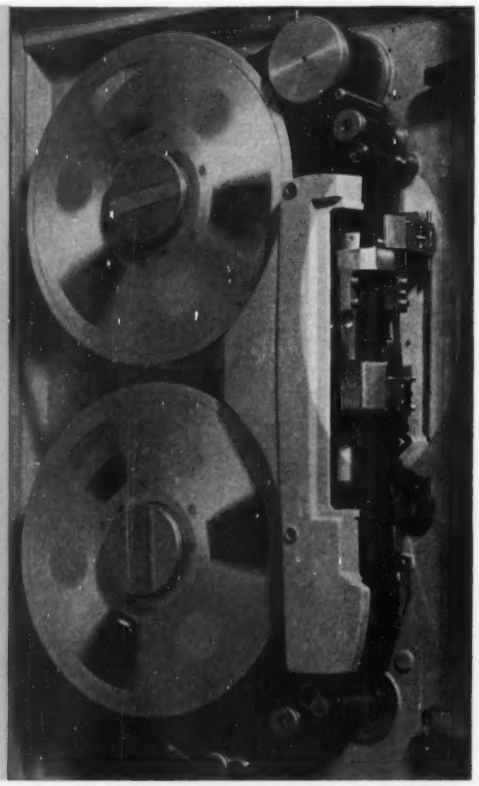
Dual centrifugal elements provide extra time delay to enable electric motor to attain full speed before picking up load. The clutch assembly is started in motion by friction caused by the motor shaft revolving within the assembly. After the assembly is up to speed, centrifugal force swings clutch weights outward to engage the drive drum. The clutch is then positively driven. Next, a second pair of weights engages the driven drum, providing a positive drive from motor to load. Two-stage pump-drive arrangement permits oil-burner blower to attain full speed before fuel pump is engaged. Principle employed in oil burner developed by Esso Standard Div., Humble Oil & Refining Co., New York.

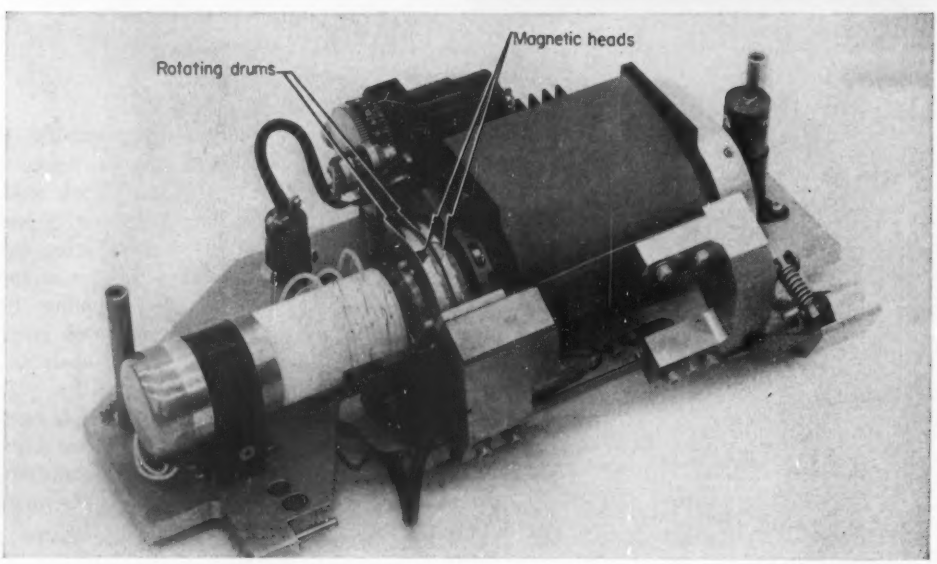


Spring wind-up absorbs variations in torque loads to reduce shock loads on the drive motor. A preloaded torsion spring permits relative rotation of 300 deg between coupling halves. Rubber-mounted stops engage lug on shaft to limit relative rotation. Spring coupling principle employed in weaving looms developed by Siemens-Schuckertwerke AG, Erlangen, Germany.

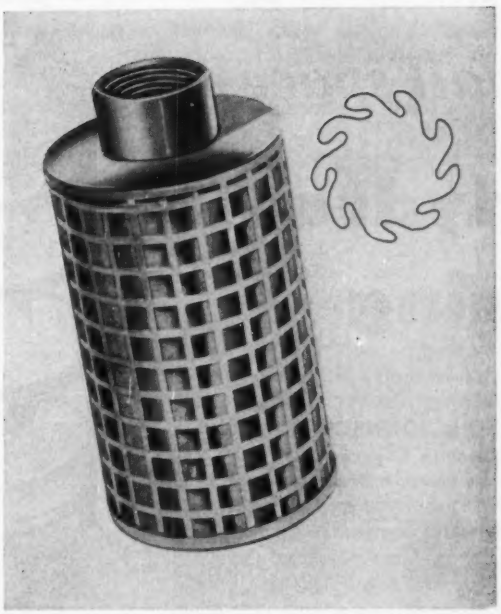
Rotating magnetic heads produce head-to-tape speed approximately 100 times greater than reel-to-reel tape speed. Four miniature heads are mounted 90 degrees apart on the periphery of a drum which rotates perpendicular to direction of tape travel past the head. The relatively wide tape is guided into an arc as it passes the rotating drum. Recording of the data is continuous since all the heads are fed the same signal and one head is always in contact with the tape. Recording principle employed in data recorder developed by Ampex Corp., Redwood City, Calif.



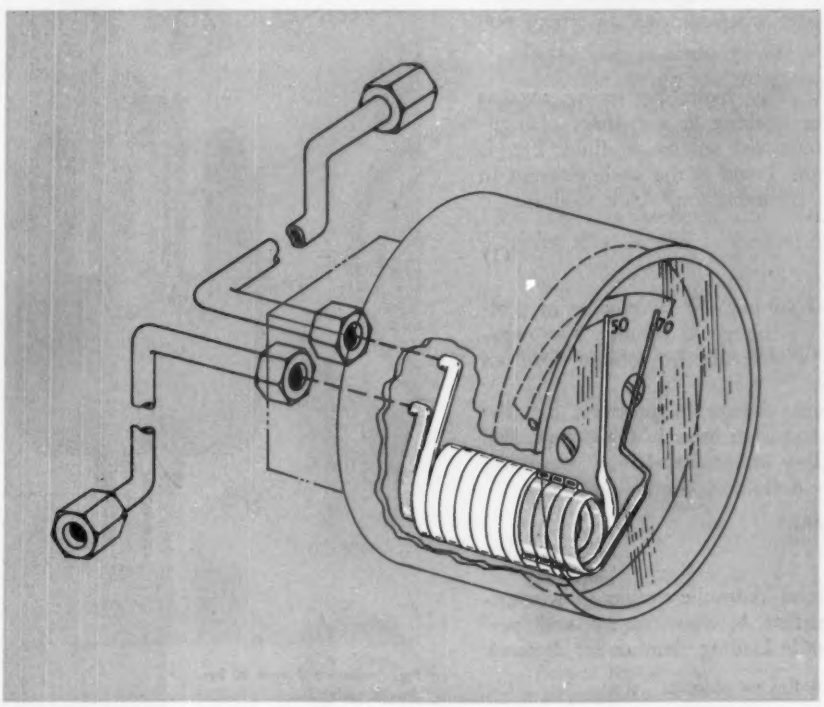




Involute surface contours of a wire-cloth filter element provide large filtration area in minimum space. The long involute folds produce approximately three times the filtering area of a cylindrical filter of the same outside dimensions. Screen principle employed in filter developed by Arrow Tools, Inc., Chicago.



Concentric Bourdon tubes provide comparative readings of separate system pressures. Each tube produces sufficient rotational deflection at its free end to permit direct indication without use of linkage or gears. Principle employed in pressure gage developed by Glassco Instrument Co., Pasadena, Calif.



For high energy storage in small space...

The Hydraulic Spring

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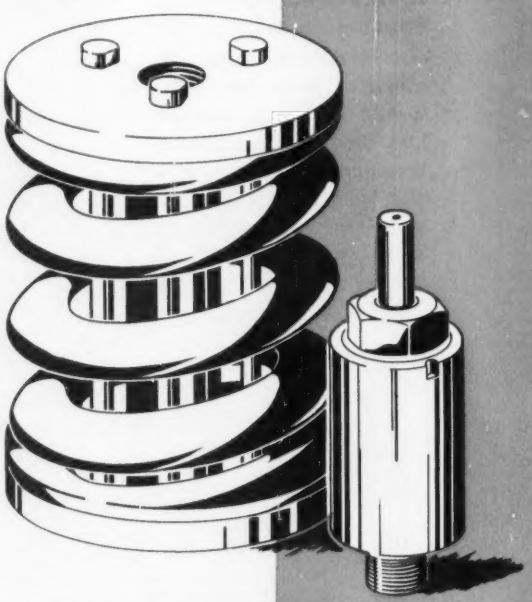


A HELICAL spring and a hydraulic spring, the equivalent in energy capacity, are roughly equal in weight, but the hydraulic spring is conspicuously smaller. As for functional space requirements, the hydraulic spring, though somewhat the larger, is comparable to the theoretical tension bar. In energy-to-weight ratios, standard hydraulic springs are available for absorbing 600 to 900 in.-lb per lb.

Basic Properties: The hydraulic spring consists of a sealed plunger working in a cylinder of high-finish against an enclosed volume of fluid, Fig. 1. Bulk modulus of the liquid is the basic element in the spring theory. By definition,[1] bulk modulus

$$B = -\frac{V\,dP}{dV} \qquad (1)$$

where V = initial volume, dP = change in pressure, psi, and dV = change in volume. The negative sign denotes a decrease in volume with an increase in pressure.

For an increment change in pressure, dP, the increment change in piston force is $dF = A\,dP$, Fig. 2. The corresponding increment change in volume is $dV = A\,dx$. By definition, the spring rate

$$K = \frac{dF}{dx} = -\frac{A^2 B}{V} \qquad (2)$$

Tests of commercial hydraulic springs show somewhat closer agreement between theory and performance under static loading than under dynamic

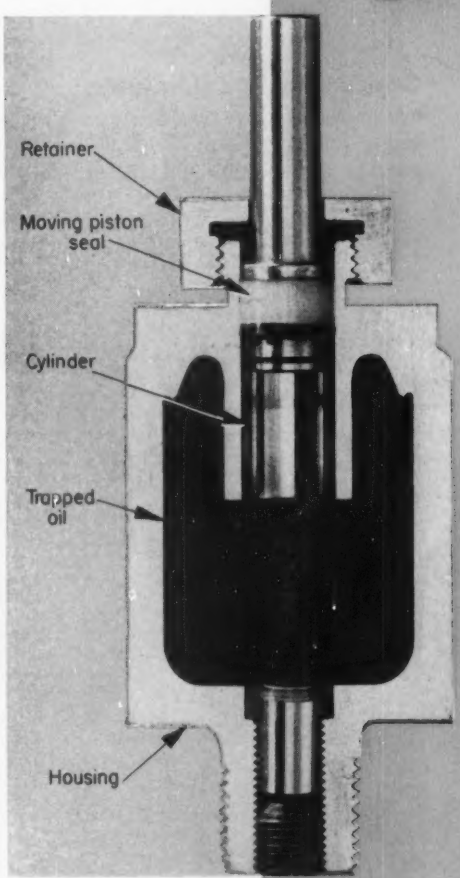
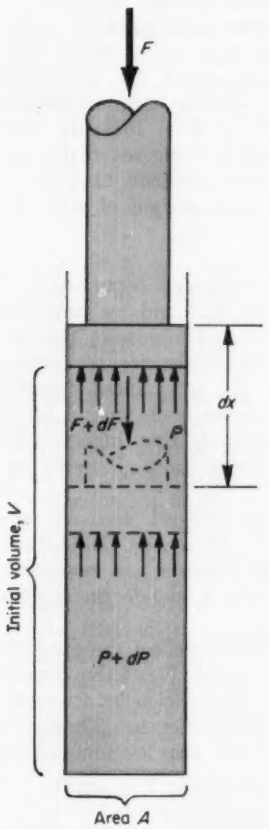


Fig. 1—Sectional view of hydraulic spring.

[1]References are tabulated at end of article.

Fig. 2—Schematic of hydraulic spring.



loading. These differences are attributed largely to mechanical losses inherent to hydraulic springs. Various spring properties and how they affect spring behavior are discussed briefly here.

Influence of Bulk Modulus: Bulk modulus of a given liquid varies slightly with pressure; hence, spring rate is nonlinear. The curvature of the curves in Fig. 3 is indicative of the magnitude of the variation in bulk modulus with pressure.

Bulk moduli of liquids differ considerably. The average values shown in Table 1 are typical of the range of moduli of common fluids.[2] When dP is large for small values of dV, Equation 1 shows that the fluid is relatively more difficult to compress than when large values of dV correspond to moderate values of dP. Thus the fluid with which a spring is filled directly affects the load-deflection performance to some extent. Bulk modulus also changes with temperature. Water, for example, exhibits a bulk modulus[3] of 293,000 psi at 32 F, 334,000 at 130 F, and 300,000 at 212 F. For this reason the hydraulic spring is somewhat sensitive to moderate changes in temperature and the preloading may change.

Preload: Normally the hydraulic spring carries a preload. That is, the fluid completely fills the cavity and is under pressure even when the spring is extended to its maximum free length. The magnitude of preload is generally set by spring manufacturers but can be altered to suit service conditions.

The intercepts of the loading curves of Fig. 3 indicate the magnitudes of preload. Upon being loaded, the spring undergoes no displacement until the applied force reaches the equivalent of the preload plus the coulomb friction.

Hysteresis: Hydraulic-spring hysteresis is illustrated by the area between the loading and unloading curves, Fig. 3. These curves represent the results

Table 1—Average Bulk Modulus of Various Fluids

Fluid	Average Bulk Modulus (psi)
Water	300,000
Kerosene (JP-1)	200,000
Heavy Medium Turbine Oil	250,000
Skydrol (Monsanto Chemical Co.)	328,000
Esso Turbo Oil 15 (MIL-L-7808 Diester)	240,000
81406 Silicone (General Electric Co.)	150,000

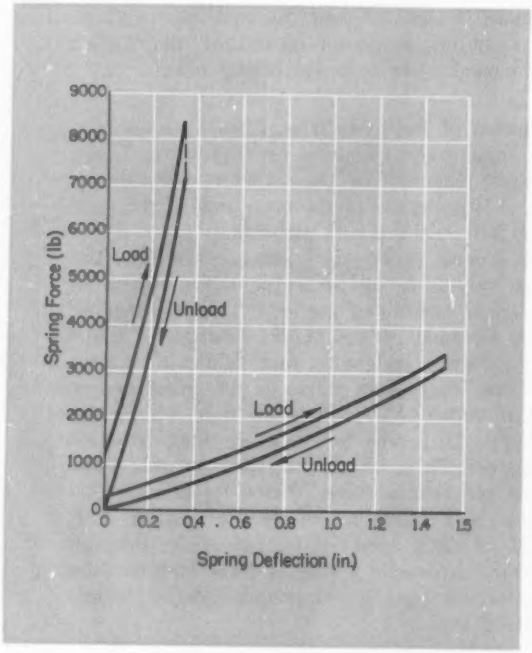


Fig. 3—Typical loading and unloading curves for two Wales-STRIPPIT hydraulic springs. One has ⅜ in. stroke at max load of 8500 lb and the other a 1½ in. stroke at max load of 3800 lb.

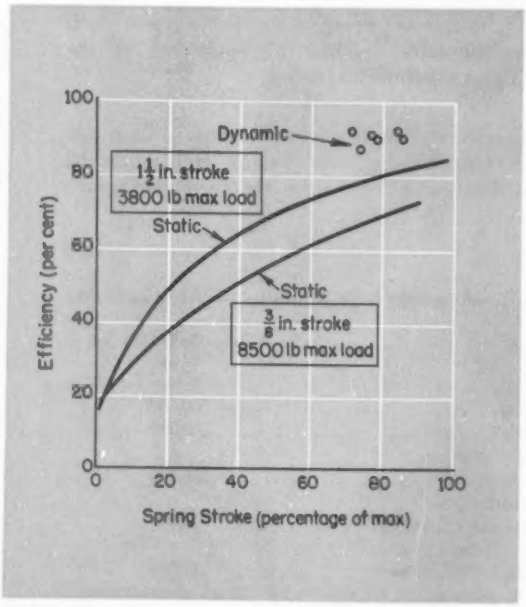


Fig. 4—Static and dynamic efficiencies of hydraulic springs of Fig. 3.

of static tests on standard, off-the-shelf, commercial springs. The data for the curves were obtained upon a Rhiele testing machine having a rate of head travel of 2 in. per min, and less.

Energy losses within the spring are predominately coulomb or friction losses, and, for a given small increment of stroke, are nearly constant over the useful range. Good spring design dictates the use of low friction, nonmetallic seal elements such as nylon and Teflon and bore finishes of at least f8.

Although published friction coefficients for nylon and Teflon range between 0.04 and 0.14, the friction forces generated in the spring can be significant. The fact that the loading and unloading curves, Fig. 3, are nearly parallel indicates that the friction within the springs being tested did not change appreciably with change in load. One source of friction is the seal. In some designs of seals the friction increases with load.

Efficiency: Work recovered versus input work at various stroke positions can be found by graphical integration of the loading and unloading curves, Fig. 3. The resulting static efficiencies are shown by the curves in Fig. 4. The pronounced dependence of efficiency on the stroke is obvious. A property of the hydraulic spring is that highest efficiencies occur near the upper limit of spring capacity.

Another property is that preload does not appreciably alter the highest efficiencies. Differences in the amount of preload, however, are noticeable in the efficiencies at low and moderate percentages of stroke.

Static tests do not necessarily reflect the dynamic efficiency of the hydraulic spring. Fig. 4 shows some dynamic test data in which the efficiencies are somewhat higher than the static efficiencies. These and a few other data from dynamic tests are summarized in Table 2.

Cycle Frequency: Tests indicate that the steady-state frequency of loading hydraulic springs generally should not exceed 1 cps. Hydraulic springs, however, will function satisfactorily under transient

Table 2—Summary of Dynamic Spring Test Data

Run	Cycle	Velocity (ft per sec) V_i	Velocity (ft per sec) V_o	Efficiency $(V_o/V_i)^2$	Amplitude (in.)
1	1	9.04	8.65	0.915	1.26
	2	8.49	7.95	0.875	...
	3	7.82	7.47	0.912	...
2	1	8.96	8.27	0.851	1.26
	2	8.29	7.87	0.902	1.15
	3	7.73	7.38	0.911	1.07
3	1	9.01	8.52	0.893	1.29
	2	8.32	7.90	0.894	1.17
	3	7.75	7.19	0.861	1.10

Average efficiency = 0.890

Pioneers of Compressibility

Liquid compressibility has intrigued investigators for centuries. Early experiments were conducted on water at the Florentine Academy. The pressure vessel was lead. Measurement techniques were inadequate to detect compressibility of less than one per cent. These conditions of the times led to the conclusion that water was incompressible.

Although Francis Bacon (1561-1626) has been credited with the experimental proof of the compressibility of water, the earliest reference in the transactions of the Royal Society is a paper by John Canton in 1762. The title of the paper is "Experiments to Prove that Water is Not Incompressible," but an unfortunate omission of the "Not" in the index led to frequent misquoting of the article.

A host of papers followed the publication of Canton's paper, culminating in the classic treatise by Amagat in 1893. Amagat contributed a vast amount of experimental data. His investigations attained pressures as high as 50,000 psi, and pertain to water not only in the liquid state but also as a gas.

References 5 to 8 at the end of the article have historical interest.

loads of higher frequency so long as the over-all duty cycle does not exceed the steady-state value.

The limit on steady-state frequency is mainly a consequence of hysteresis. This limit is a function of the individual spring (seal geometry), the heat-transfer properties of the spring and mounting, spring preload, and stroke. Although upper limits to cycling are generally recommended by manufacturers, the top frequency, to be reliable, must be established on an individual basis.

Spring failures at high frequencies are normally caused by overheating because of the frictional hysteresis. When the heat so generated becomes greater than the steady-state heat output, the oil temperature rises above ambient temperature and causes excessive pressure, excessive wear, and eventual leakage with a subsequent loss in preload. With high-frequency inputs, this condition can be reached in a short time.

Types of Applications: The high energy to weight and volume ratios preclude the use of hydraulic springs for other than heavy-duty applications. Hydraulic springs are used widely in machine tools, particularly in punch and die assemblies.

Piston weight or dynamic mass of the hydraulic spring is small in comparison with the coil weight of an equivalent helical[4] spring (on the order of 5 to 10 per cent versus 33 per cent). This property makes the hydraulic spring attractive for use as an energy absorber or buffer. The high natural frequency and coulomb damping rapidly quench transient oscillations that result from collision impacts. Spring rates approaching 20,000 lb per in. are available commercially.

Uses other than tooling include recoil springs and buffers for conventional gun systems and accelerator springs for seared-mass systems. Hydraulic springs have demonstrated high-frequency capabilities in spring-mass systems. A transient tester was devised that oscillated a 200-lb H beam at 100 cps with a 90 per cent amplitude decay in approximately 3 cycles.

When used as a temporary energy-storage device such as a spring buffer or stripper, the dynamic efficiency is quite good. However, since at lower pressures the compressibility closely parallels a thermodynamic compression, long-term energy storage is not feasible.

In the design of spring buffers, hydraulic springs may be treated as equivalent conventional springs by familiar potential energy techniques. The error introduced by nonlinearities are not severe. When used as seared-mass accelerators, provisions must be made to stop the motion of the piston by external means. While the piston mass is relatively low, the kinetic energy at 100 fps or more is sufficient to fracture piston retainers.

The hydraulic spring has the additional merit of fail-safe. Failure of the hydraulic spring results in the loss of fluid which may or may not be harmful. In contrast failure of a mechanical spring involves the added danger of flying bits of spring steel that may jam in gear teeth, in die cavities, and elsewhere to wreck a machine and that may cause injury to workmen.

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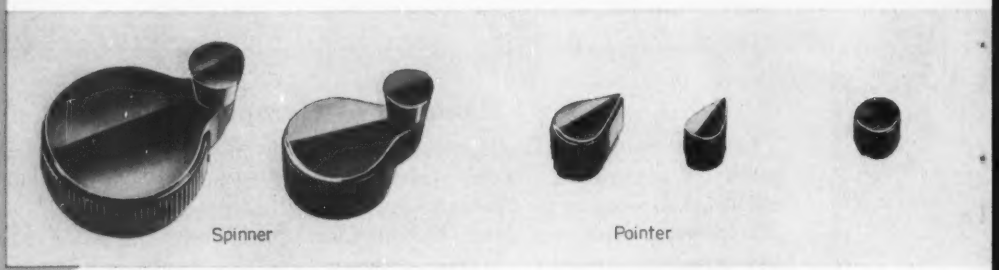


Fig. 1 — Basic shapes of knobs.

Photo courtesy Raytheon Manufacturing Co.

A design guide to selection and application of KNOBS

CONTROL knobs on instruments form a link between the operator and the instrument's function. Regardless of whether the knob is used for coarse or fine adjustment, a number of factors should be considered to obtain a proper match between the knob and a particular control:

1. Torque required to turn the control.
2. Angular rotation normally required for positioning control.
3. Positional accuracy required for setting control.
4. Ambient lighting for control adjustment.
5. Adjustment of controls when operator wears gloves.
6. Time available for making adjustment.
7. Space available on panel for control knob.
8. Control locking required.

A quick analysis of all these factors indicates that there are two main considerations in knob selection—size and shape.

Knob Size: Determining factors are 1, 3, 5, and 7. A few more considerations apply particularly to size.

A knob should be large enough to permit easy turning of the control. But it should not be so large that, under a heavy hand, it becomes a lever strong enough to cause damage.

Where an oversize knob is used for rapid positioning, it should have a bulit-in clutch which is set to slip before damaging torque is reached.

Knob Shapes: Knobs are made in many shapes, from simple round types to more elaborate kinds with skirts or spinners, Fig. 1. Principles of human

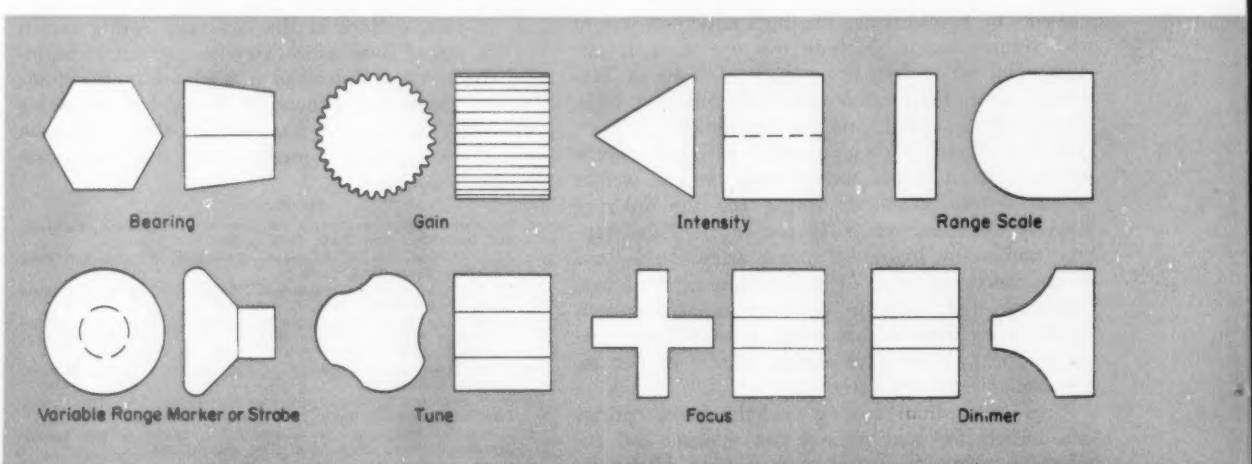
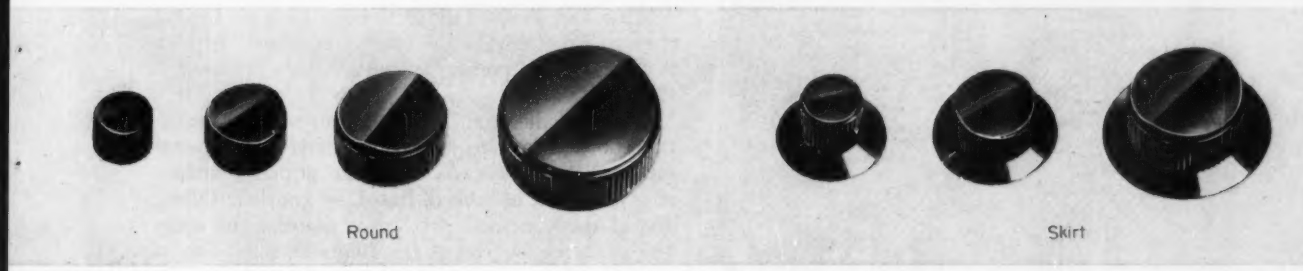


Fig. 2—Preferred knob shapes for tactile identification based on military specifications.



FRANK WILLIAM WOOD JR., Engineer
Systems Development Dept., Vitro Laboratories, Silver Spring, Md.

engineering influence selection and design of knob shapes. Hence each shape is usually used to produce a specific control motion:

1. Round knobs are suitable for controls which require smooth, continuous rotation through more than one revolution. Highly accurate positioning may be secondary.
2. Spinner knobs are suitable for multiple-turn controls which require rapid positioning.
3. Various geometric shapes, Fig. 2, can be used for rotation less than one revolution, or when a control must be identified by touch, as in military applications.
4. Lever knobs, Fig. 3, should be used when a control is torqueloaded to return to original position when released, or when torque required to rotate a control would require an excessively large round knob. For

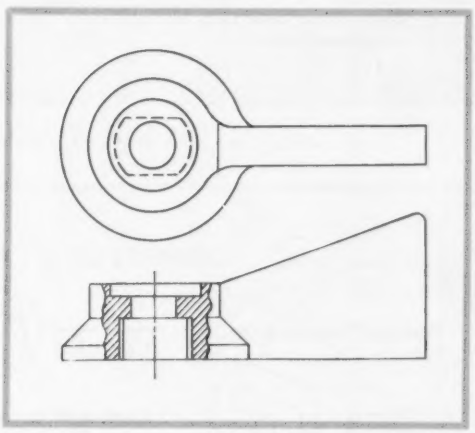
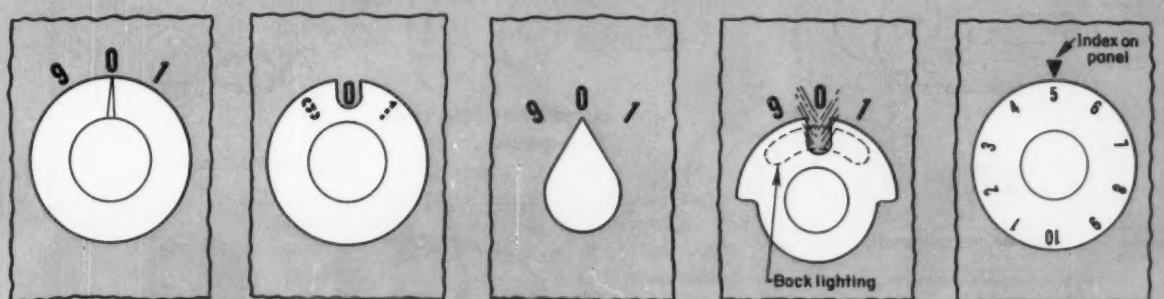


Fig. 3—Lever knobs designed to exercise control by applied torque.



a. Skirted knob with index marker. All settings are always visible. Operator can see which way to turn to increase or decrease control.

b. Skirted knob with cut-out. Minimum required information is visible.

c. Pointer knob. Same advantages as knob a, but less bulky.

d. Cut-out skirt with back-lighting. Advantages of knobs a and b, plus illumination.

e. Skirted knob and fixed painter. Operator always reads pointer position.

Fig. 4—Ways to use pointers.

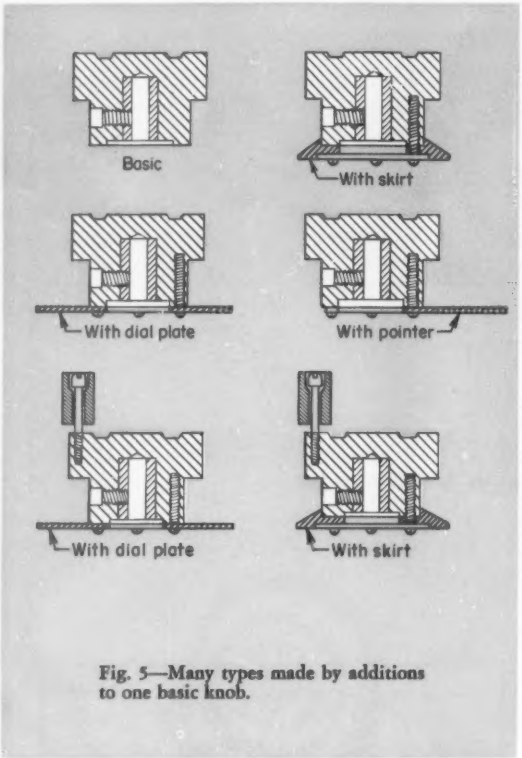


Fig. 5—Many types made by additions to one basic knob.

rotation less than one turn, bar knobs can serve the same purpose.

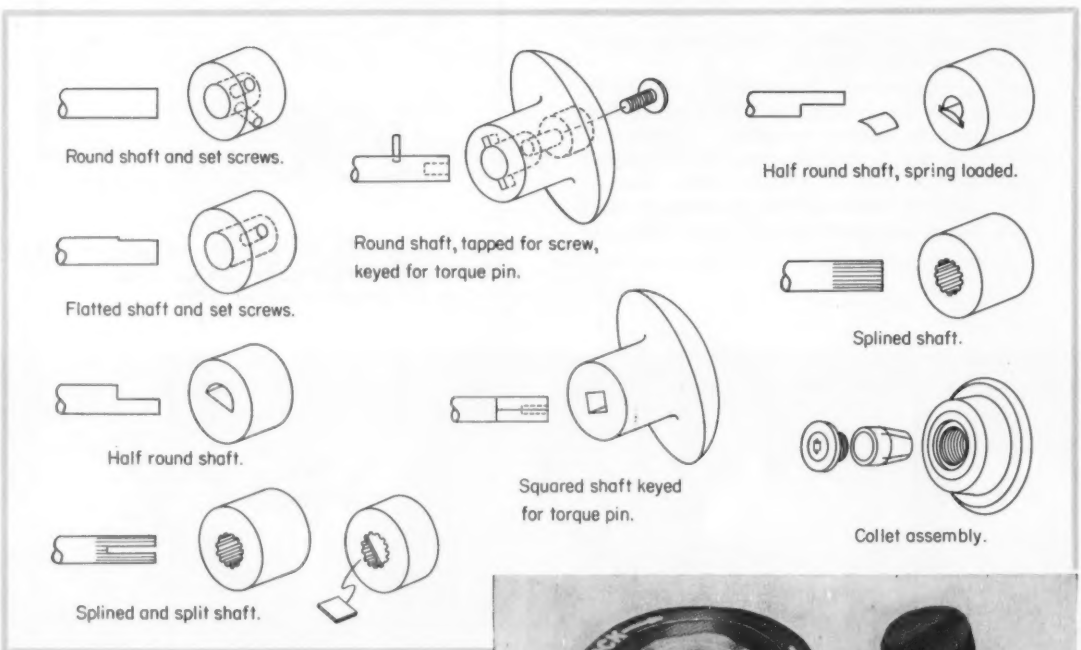
Skirts and pointers added to basic knob configurations indicate quickly the relative positional settings of controls. Position can be indicated in several ways, Fig. 4.

Where tactile identification is not required, addition of details can make one basic shape serve many purposes, Fig. 5. Also, the gripping surface of a knob can be ribbed, fluted, or knurled. Often, one of these methods is used to increase the operator's torque where space limitations require a small knob to be used.

Knob Fasteners: Methods for attaching knobs to shafts vary from simple push-on friction-fit, which requires no tools, to more elaborate collet-fitting, Fig. 6. Selection of fastening methods depends on:

1. Shape of control shaft.
2. Control shaft material.
3. Knob material.
4. Ease of removal desired.
5. Environmental conditions, such as vibration and shock.
6. Relative phasing required between knob and shaft.

Knob Locks: It may be desirable to lock a knob in a certain position to prevent changes in a critical setting. One example is shown in Fig. 7. It takes up very little panel space, and is available with a pointer knob for increased reading accuracy.


Round shaft and set screws.
Round shaft, tapped for screw, keyed for torque pin.
Half round shaft, spring loaded.
Flatted shaft and set screws.
Splined shaft.
Half round shaft.
Squared shaft keyed for torque pin.
Collet assembly.
Splined and split shaft.

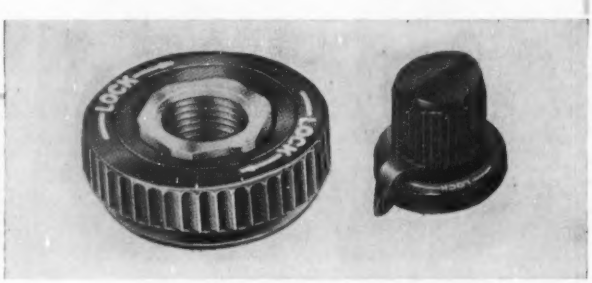


Fig. 6—Above—Ways to attach knobs to shafts.

Fig. 7—Right—Knob lock combined with pointer.

Auxiliary Component Arrangements for Torque Converters

Direct Drive • Retarding • Split Torque

H. J. WIRRY R. W. BACHMANN R. C. SCHNEIDER
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Rockford, Ill.

INHERENT operating characteristics of torque converters may need to be altered or augmented in some situations. Auxiliary components can be added to provide direct drive, retarding, or torque splitting in the particular application requiring these features.

Direct Drive

Direct-drive arrangements are advantageous for certain vehicle applications in which a major portion of the work cycle is spent in high-speed travel. The converter is used for starting and for working under heavy or variable loads. Then, the unit is shifted to direct drive for long-haul or steady-speed operation on level or nearly level terrain.

Lock-out Arrangement: A clutch and a free-wheeling system for bypassing the converter are combined to obtain direct drive. This is the direct-drive system which is used with stationary - housing

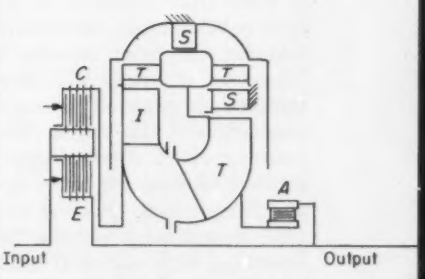


Fig. 1—Lock-out clutch arrangement *DF*—direct drive, one freewheeling clutch.

type converters. Isolating the converter from the drive system during direct drive eliminates the losses which would result from circulating fluid through the stationary-housing circuit.

Fig. 1 shows a typical *DF* arrangement; the letter *D* designates direct, the letter *F* designates one freewheeling clutch. The same basic arrangement could be used with a three-stage converter or a type 4 converter. The operation is:

Neutral—Converter-drive clutch *C* and direct-drive clutch *D* are both disengaged.

Converter Drive—Clutch *C* is engaged and clutch *D* is disengaged, permitting normal converter operation by transmission of power from the prime mover to impeller *I*. Freewheeling clutch *A* engages to transmit power from turbine *T* to the output load.

Direct Drive—Clutch *C* is disengaged and clutch *D* is engaged. No power is transmitted to impeller *I*, and freewheeling clutch *A* overruns and disengages. Impeller *I* and turbine *T* are free to drift to a stop. Power is transmitted directly from the prime mover through clutch *D* to the output load.

To prolong the life of the clutches, the power flow should be interrupted or the engine speed reduced when the shift is made from converter drive to direct drive. The shift-control system can be arranged so that clutch *C* is disengaged before clutch *D* is engaged. Thus, the turbine can be released before power is transmitted through clutch *D* to the output shaft. An overlap of engagement of clutch *C* and clutch *D* under full power produces a needless power loss due to a torque absorption by the impeller.

The power flow is automatically interrupted when the shift is made from direct drive to converter drive. As clutch *D* is disengaged and clutch *C* is engaged, the idle impeller will not be able to absorb full engine power until it is accelerated to engine speed.

Fig. 2 shows another arrangement, designated *DFF*—direct drive and *two* freewheeling clutches. Freewheeling clutch *A* serves the same purpose as freewheeling clutch *A* in the *DF* arrangement. Engine speed is momentarily reduced when the shift is made from converter to direct drive. While the shift is being made, freewheeling clutch *B* overruns, allowing the inner member of clutch *D* to stop. Therefore, clutch *D* will always engage with both members at relatively low speed. After clutch *D* is engaged, and the engine throttle is opened, freewheeling clutch *B* will engage. Then, power will be transmitted from the prime mover through clutch *D* and freewheeling clutch *B* to the output load. The *DFF* arrangement permits "coasting" without any retarding, while clutch *D* is engaged at reduced engine throttle.

Lock-up Arrangement: The converter impeller and turbine are clutched together or "locked up" to provide a direct drive from prime mover to output load. This arrangement is useful with rotating-housing converters.

Fig. 3 shows a lock-up clutch arrangement as used with a type 1 converter. The same basic arrangement could be used with type 7 or type 8 converters. The operation is:

Neutral—A neutral can be provided with a master clutch somewhere else in the system, before or after the converter.

Converter Drive—Clutch *L* is disengaged, permitting normal converter operation by transmission of power from the prime mover through impeller *I* and turbine *T* to the output load.

Direct Drive—Clutch *L* is engaged, locking impeller *I* and turbine *T* together. Power is transmitted mechanically, rather than hydraulically, from the prime mover to the the output load.

Interruption of power flow is not necessary during the shift from converter drive to direct drive with a lock-up clutch, since both the impeller and the turbine are members of the mechanical drive after lock-up.

Hydraulic Losses: In a lock-out clutch system both rotating converter-circuit elements are out of the drive system during direct-drive operation. However, because the two clutches usually are operated hydraulically, there is a slight loss at all times due to clutch drag and power required to drive a hydraulic pump to supply the clutches.

The lock-up clutch system with a fixed-stator converter has hydraulic loss during direct-drive operation. This loss is equal to the torque absorption at 1.0 speed ratio and will vary as the square of the speed. The loss is greater with a type 7 converter because there are two rings of stator blades. These losses are particularly great in the larger sizes of type 7 converters. Hydraulic loss with a type 8 converter is negligible because the stator can freewheel during lock-up. Although there is some clutch drag at all times, no supply pump is necessary because hydraulic pressure to actuate the clutch is taken from the regular converter cooling-pump circuit.

The type 6 converter is not suitable for lock-up clutch operation because the torque absorption at 1.0 speed ratio is quite high. Therefore, the hydraulic loss in lock-up drive would be excessive.

Retarding

Retarding effort may be obtained in vehicles or hoists by:

Hydrodynamic retarding—One or both rotating circuit elements are locked to the ground-driven or load-driven output shaft.

Engine retarding—Engine crankshaft is locked to the ground-driven or load-driven output shaft.

Selective Retarding: Retarding effect is obtained in the *DF* arrangement, Fig. 1, by closing the engine throttle to idle and engaging both clutch *C* and clutch D. The output shaft will tend to drive the engine and impeller *I*. Freewheeling clutch *A* will

overrun and turbine *T* will be free to drift, offering little or no retarding. However, impeller *I* will provide considerable retarding effect because it will be absorbing torque from the output load.

No retarding will be available in the *DFF* arrangement, Fig. 2, because both freewheeling clutch *A* and freewheeling clutch *B* will overrun. Therefore, there would be no mechanical connection between the output shaft and the engine or the converter elements. A locked-turbine arrangement can be used with the *DF* design. In this system, a third clutch is added to lock the turbine in a stationary position while the hydraulic-drive clutch and direct-drive clutch are both engaged for retarding. This arrangement gives maximum retarding effect from the converter because the retarding torque is the input torque at stall at engine speed. This design has mechanical limitations and cannot be used readily on large converters.

The lock-up clutch arrangement shown in Fig. 3 is used in types 1, 7, and 8 converters. It provides engine retarding if the throttle is closed and clutch *L* is engaged. In addition, there will be some hydrodynamic retarding from the converter. The retarding will be equal to the lock-up loss or the converter torque absorption at 1.0 speed ratio.

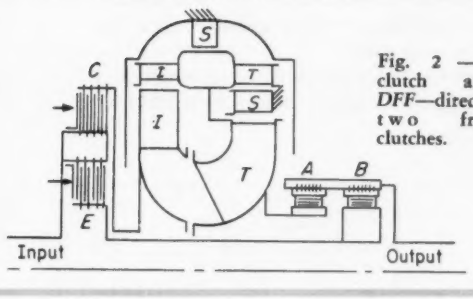


Fig. 2 — Lock-out clutch arrangement *DFF*—direct drive, two freewheeling clutches.

Converter retarding effect is considerably less with rotating-housing converters than with stationary-housing converters of similar size. However, additional retarding effect can be obtained from an auxiliary hydraulic retarder installed in the driveline behind the converter or built into the converter unit in special designs.

One type of hydraulic retarder is essentially a permanently stalled dump-and-fill fluid coupling. A bladed impeller-like element is rotated inside a similarly bladed turbine-like enclosure which is held stationary. Fluid introduced into the chamber formed by these elements produces retarding. When retarding is not required, the fluid is dumped. Retarding is controlled by varying the amount of fluid.

All the foregoing retarding methods are selective. Action is required of the operator to put the retarding effort into effect.

Nonselective Retarding: Fig. 4 shows a nonselective or automatic arrangement, *CO*, which consists of a freewheeling clutch between the input and output members. This clutch will overrun when power is transmitted from the prime mover through the converter circuit to the output shaft. When retarding is required, the engine throttle is closed. The freewheeling clutch will engage, permitting the output shaft to drive the engine and both rotating elements of the converter. The arrangement can be used in almost any converter that does not have lock-out or lock-up clutches. The *CO* arrangement is often used with a converter with an input clutch.

If space limitations are critical, the freewheeling clutch may be located at the rear end of the converter, or outboard of the circuit.

In stationary-housing converters, retarding effect of the *CO* arrangement is equal to or greater than that of the *DF* arrangement. Both give equal retarding effect if the converter would otherwise race

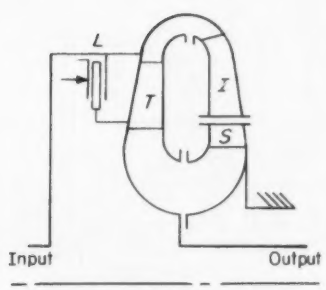


Fig. 3—Lock-up clutch arrangement.

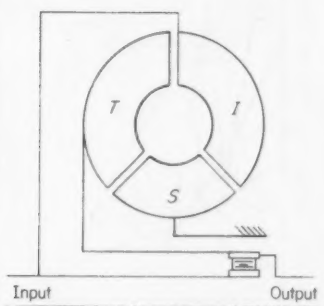


Fig. 4—Automatic-retarding arrangement.

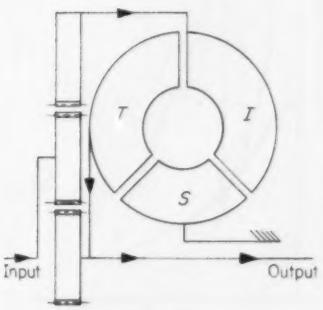


Fig. 5 — Split-torque arrangement. Split on input side of converter.

Crawler Tractors

The ability of the torque converter to adjust instantly to changing loads has proved to be essential for "push loading" of scrapers. It is also desirable for dozing, ripping, and scraper hauling. The elimination of most gear-shifting reduces cycle time and operator fatigue.

Two basic torque converter types are now used in crawler tractors—high torque ratio, three-stage and type 4 stationary-housing converters, and low torque ratio, single-stage rotating-housing converters.

The three-stage converter has the basic advantages of greater torque multiplication and broader utility ratio, permitting the use of fewer transmission ratios. Single-stage rotating-housing converters are of simpler construction, can operate on lubricating oil, and offer an easy means of obtaining auxiliary power-take-off drives.

Good overall tractor performance can be obtained with only two gear ratios by using a three-stage converter or a type 4 stationary-housing single-stage converter. Fig. A illustrates typical tractor performance with either unit. Some manufacturers prefer to use three or four speeds to obtain better speed control or to take advantage of other tractor design features.

To obtain satisfactory crawler performance with either rotating-housing single-stage or split-torque units, a minimum of three transmission speeds should be used as shown in Fig. B. Top speed of 7 to 8 mph is desirable for large tractors, whiile track slippage should occur at approximately 1.5 mph. Top speed of small crawlers is usually 5 to 6 mph.

Drive-Train Arrangements: If the transmission is of manual-shift design, as shown in Fig. C, the stationary-housing converter is easily adapted by using a conventional flywheel-mounted over-center clutch. Converter retarding automatically slows the transmission gears as soon as the clutch is released, allowing normal shifting. Use of rotating-housing converters may present some problems in this application, because inertia of the revolving elements tends to prevent easy shifting. It is recommended in this case that the master clutch be located on the output end of the converter and that some means of slowing the transmission gears be provided to allow gear shifting.

As shown in Fig. D, a master clutch is unnecessary, because each speed is controlled by a transmission clutch. The power-shift transmission can be used with any torque converter if sufficient speeds are provided. The power-shift transmission speeds up work cycles since little time is lost shifting gears and the correct ratio is easily found. The transmission is more complicated and expensive than the manual-shift transmission.

Final-drive power trains shown are conventional time-proved designs. "Split" power-train crawler

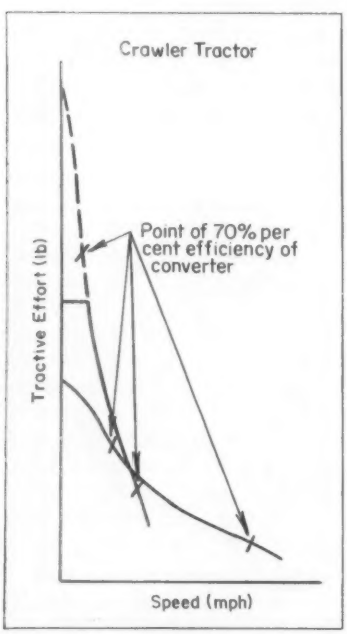


Fig. A — Tractor performance with two-speed transmission.

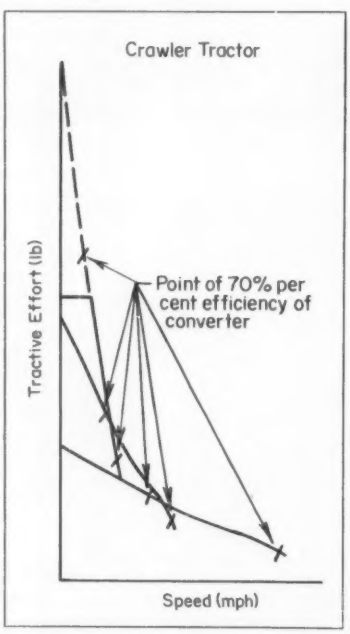


Fig. B — Tractor performance with three-speed transmission.

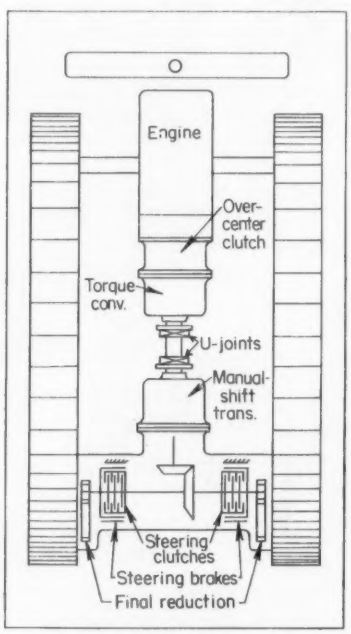


Fig. C—Tractor drive-train with manual-shift transmission.

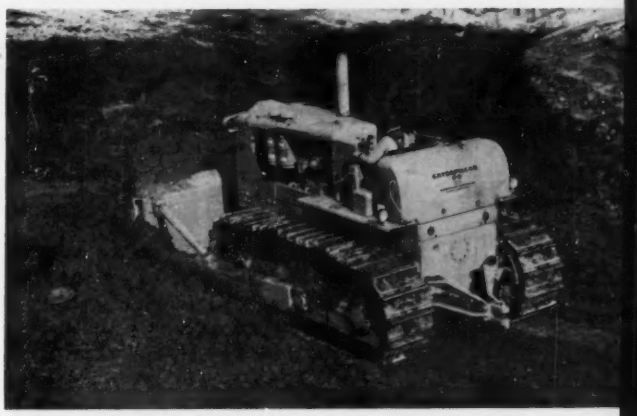
tractors are also available, featuring individual control of each track by use of separate transmissions. Some military tractors and tanks use a third type, the "cross" drive which uses a converter and direct mechanical-drive differential action to obtain controlled rate of turning speed with no break of power flow to either track. Fig. E illustrates a simple form of this drive.

Cooling is often a crawler-tractor design problem because space available for the radiator is usually limited. "Rule of thumb" converter cooling recommendations for crawler-tractor applications are undependable. It is necessary to study the entire tractor heat rejection (engine, converter, transmission, and final drive) and provide adequate cooling over the range of normal operation.

Performance Considerations: Crawler tractor engines are usually selected to provide approximately 10 hp per ton of tractor weight. However, there is a current tendency to increase this ratio to provide faster operation at speeds above track-slippage speed.

Once the engine and converter are selected for a crawler-tractor installation, the performance curve of the engine-converter unit can be calculated and plotted. From this curve, performance characteristic of the tractor can be estimated.

The basic tractor performance characteristic usually evaluated is tractive effort, or the tractive force along the surface of contact between the tracks and the ground over which the tractor is traveling.



Photo, courtesy Caterpillar Tractor Co.

The tracks of a crawler tractor will slip whenever tractive effort available is sufficient to cause the grousers to tear away the surface of the ground over which the tractor is traveling. This will be determined by the transmission and final-drive gearing, the weight of the tractor, and the "adhesion factor." The adhesion factor varies with soil conditions and moisture content, but an average figure for good soil conditions is 0.85.

Most crawler tractors are powered and geared to slip the tracks in low gear, and possibly even in second gear if the power to weight ratio is very high. The tracks will slip when the product of the tractor weight and adhesion factor exceeds tractive effort available.

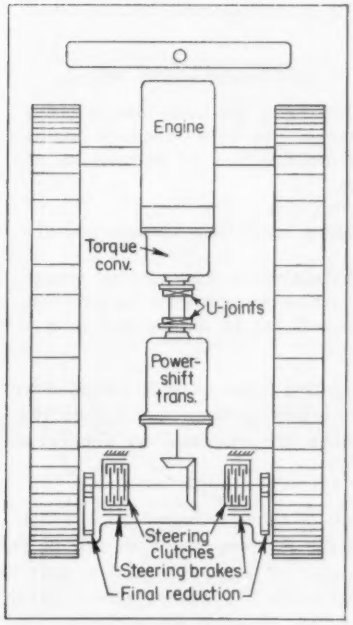


Fig. D—Tractor drive-train with power-shift transmission.

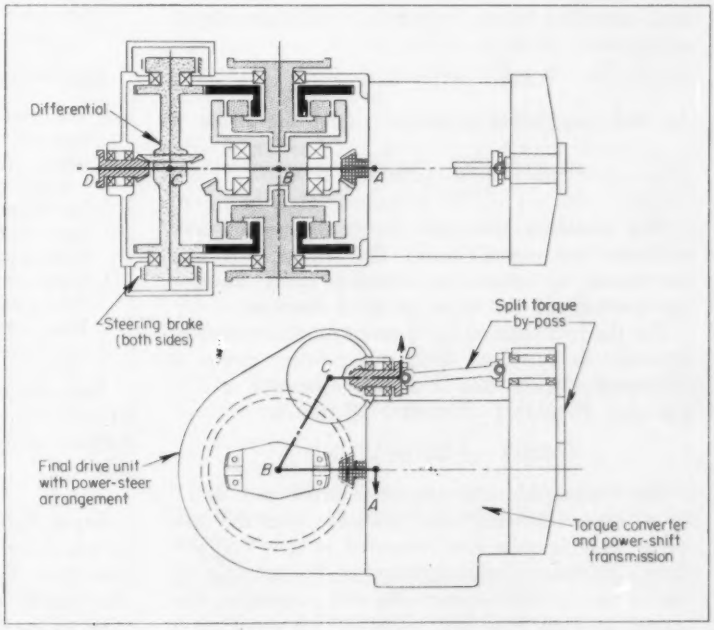


Fig. E—Tractor final-drive with power-steer.

at or beyond 1.0 speed ratio, because either arrangement forces such a converter to run at 1.0 speed ratio. However, if the converter would otherwise race below 1.0 speed ratio, it would go to race with a *DF* arrangement, but to 1.0 speed ratio with a *CO* arrangement. The latter converter would offer more retarding effect at 1.0 speed ratio than at race, because the retarding torque at 1.0 speed ratio would be the torque absorbed by the impeller as well as the torque absorbed by the turbine.

In rotating-housing converters, retarding effect of the *CO* arrangement would be the same as that of a lock-up clutch. With either rotating-housing or stationary-housing converters, retarding with the *CO* arrangement would be automatic whenever the output-shaft speed exceeds the input-shaft speed. The nonselective retarding provided by the *CO* arrangement is considered an advantage in many applications.

Determination of Retarding Effect: For most models of converters, the retarding effect is actually determined experimentally. These data, plotted against converter speed, are available in standard sheet form. However, for converters which race at or beyond 1.0 speed ratio, retarding effect available with a *CO* or *DF* arrangement or lock-up clutch can be estimated easily from primary torque and efficiency data. The retarding effort available at 1700 rpm input speed is the primary torque at 1.0 speed ratio multiplied by the inefficiency of the converter.

For example, Fig. 8 in Part 3 of this series[3] shows the primary torque and efficiency of a type 6, 1500 series M_s-280 converter. The primary torque at 1.0 speed ratio is 206 lb-ft, and the efficiency is 70.7 per cent. The inefficiency is (100 − 70.7) or 29.3 per cent. Retarding torque, therefore, at 1700 rpm (input or output) is

$$206(0.293) = 60 \text{ lb-ft}$$

At 1800 rpm (input or output), retarding torque is

$$60\left(\frac{1800}{1700}\right)^2 = 67 \text{ lb-ft}$$

The retarding effect can be determined at any converter (or engine) speed. The engine speed can be related to vehicle or hoist-line speed through the gearing and the wheel or drum diameter.

For the hypothetical 8,800 series M_s-470 converter discussed in Part 3 of this series, primary torque at 1.0 speed ratio is 232 lb-ft and efficiency is 23.5 per cent. Retarding effort at 1700 rpm is

$$232(1 - 0.235) = 177 \text{ lb-ft}$$

For rotating-housing converters which race at 1.0 speed ratio, retarding effort available from the converter only is quite low compared to that available from a stationary-housing converter. For example, for the type 7, 1500 series M_s-285 converter discussed in Part 4 of this series, at 1.0 speed ratio, primary torque is 20 lb-ft and efficiency is zero. Therefore, retarding effort at 1700 rpm is 20 lb-ft.

[3]References are tabulated at end of article.

Since the three converters in the above examples could all be used with the hypothetical 100-hp engine, a fair comparison of the retarding available from various types of converters is obtained. The freewheeling clutch or lock-up clutch mechanically connects the load to the engine during retarding. Therefore, the retarding effect of the engine is available regardless of the retarding characteristics of the converter.

Split Torque

Power of a prime mover can be transmitted to the output load through a split-torque drive. Part of the torque is transmitted hydraulically through a torque converter and the remainder is transmitted mechanically directly to the output shaft. The split can be provided by a planetary gear set before or after the converter.

Advantages of split-torque drives are:

1. The peak efficiency of a split-torque unit consisting of a converter and a planetary gear set will be greater than that of the converter drive.
2. The converter portion of a split-torque drive can be of a smaller size than the converter of a pure converter drive.
3. A split-torque unit will pull down a prime mover further at stall than will the same type of converter of the proper size. This characteristic is an advantage in vehicle applications in which it is convenient for an operator to judge engine speed by sound.
4. Inertia effects of a mechanical drive are made available with a split-torque drive without destroying the smoothness and the ability to stall without killing the engine.
5. The power to heat during high-speed, low-load operation is reduced.

Disadvantages of split-torque drives are:

1. The converter portion of a split-torque drive is smaller than with a pure converter drive. Therefore, less retarding effect is available from the converter for vehicle applications.
2. The design is more costly.
3. Losses in the gearing detract from the theoretical efficiency gains.
4. Engine torsional vibrations can be transmitted through the mechanical portion of the drive to the drive line. These vibrations will not be damped out as in a pure converter drive.

Basic features of two types of split-torque drives are covered in the following discussion. Other split-torque configurations are discussed in detail elsewhere.[5]

Input Split: Fig. 5 shows schematically a split-torque drive with the split on the input side of the converter. Full torque of the prime mover goes to the carrier which holds the planet pinion gears. The torque transmitted through the outer, or ring, gear goes to the converter impeller. This torque is transmitted hydraulically to the turbine and out the output shaft. The torque transmitted through the

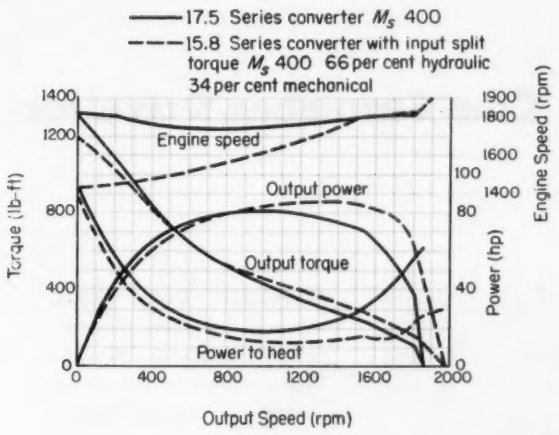

17.5 Series converter M_s 400
15.8 Series converter with input split torque M_s 400 66 per cent hydraulic 34 per cent mechanical
Engine speed
Output power
Output torque
Power to heat
Torque (lb-ft)
Power (hp)
Engine Speed (rpm)
Output Speed (rpm)

Fig. 6—Performance comparison of converter vs. converter with input-torque split.

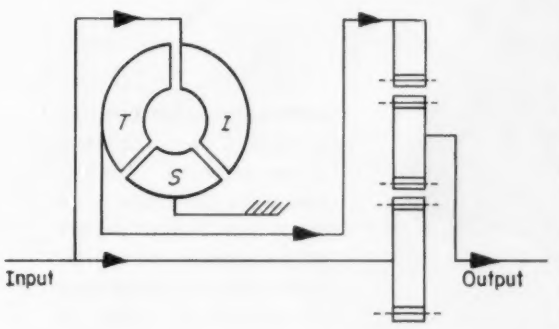


Fig. 7—Split-torque arrangement. Split on output side of converter.

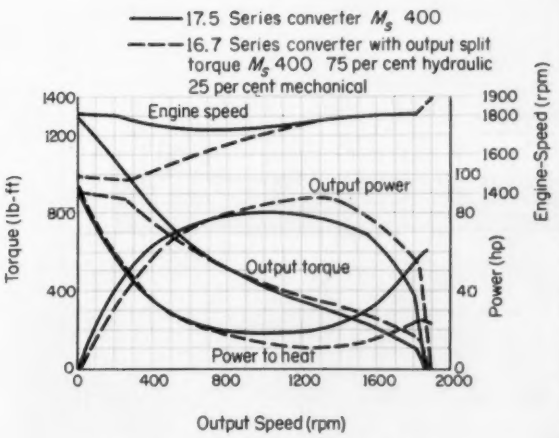

17.5 Series converter M_s 400
16.7 Series converter with output split torque M_s 400 75 per cent hydraulic 25 per cent mechanical
Engine speed
Output power
Output torque
Power to heat
Torque (lb-ft)
Power (hp)
Engine-Speed (rpm)
Output Speed (rpm)

Fig. 8—Performance comparison of converter vs. converter with output-torque split.

inner, or sun, gear goes directly to the output shaft and adds to the torque coming through the converter turbine.

Fig. 6 shows the example 100-hp engine and the hypothetical type 4, 1700 series converter discussed in Part 3 of this series compared with the same engine and a suitable size type 4 split-torque unit. The split is on the input—66 per cent to the converter and 34 per cent direct. The increase in efficiency with a split-torque unit is apparent from the higher output power in the high-speed range and from the lower power to heat throughout the entire range. Note the definite engine pull-down with the split-torque unit.

Power to heat is reduced under high-speed, light-load operation by the use of a freewheeling clutch between the input and output members of the converter, similar to the freewheeling arrangement shown in Fig. 4. This freewheeling clutch limits the converter speed ratio to 1.0 and prevents the turbine from overrunning the impeller. Thus, when there is no load on the output shaft, power absorbed by the impeller is utilized only to turn the turbine—it is not going into useful work. Power to heat is the inefficiency (100 per cent minus the efficiency) multiplied by the power absorbed by the impeller at 1.0 speed ratio.

The curves in Fig. 6 show performance at race with such a freewheeling clutch in each unit.

Output Split: Fig. 7 shows schematically a split-torque drive with the split on the output side of the converter. The prime-mover output shaft is mechanically fixed to the sun gear. However, part of the prime-mover torque goes to the impeller to be transmitted hydraulically to the turbine and on to the ring gear. At the planet carrier the torque from the turbine joins the torque which has come directly from the prime mover.

Fig. 8 shows the hypothetical 100-hp engine and the hypothetical 1700 series converter discussed in Part 3 of this series compared with the same engine and a suitable size type 4 split-torque unit. The split is on the output side—75 per cent hydraulic and 25 per cent mechanical. The increase in efficiency is apparent from increased output power and decreased power to heat. Race performance with a freewheeling clutch is also shown.

The final article in this series will discuss cooling systems and limiting devices.

REFERENCES

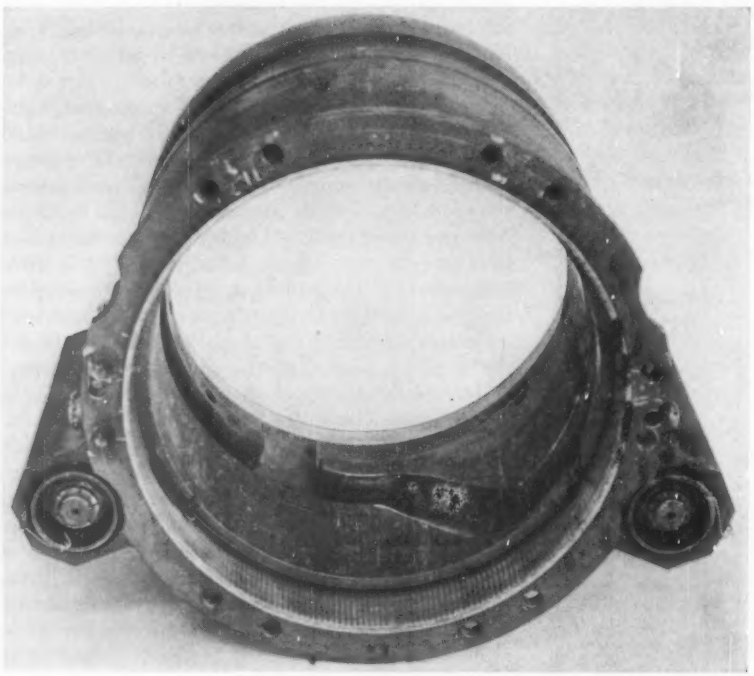
This article is the fifth in a series on hydrodynamic drives. Previous articles and issues of MACHINE DESIGN in which they appear are:

1. "Fluid Couplings" ..... March 31, 1960
2. "Basic Characteristics of Torque Converters" ..... April 14, 1960
3. "Applying Torque Converters to Prime Movers" ..... April 28, 1960
4. "Evaluating Performance Curves of Torque Converters" ..... May 12, 1960

Another reference mentioned in this article is:

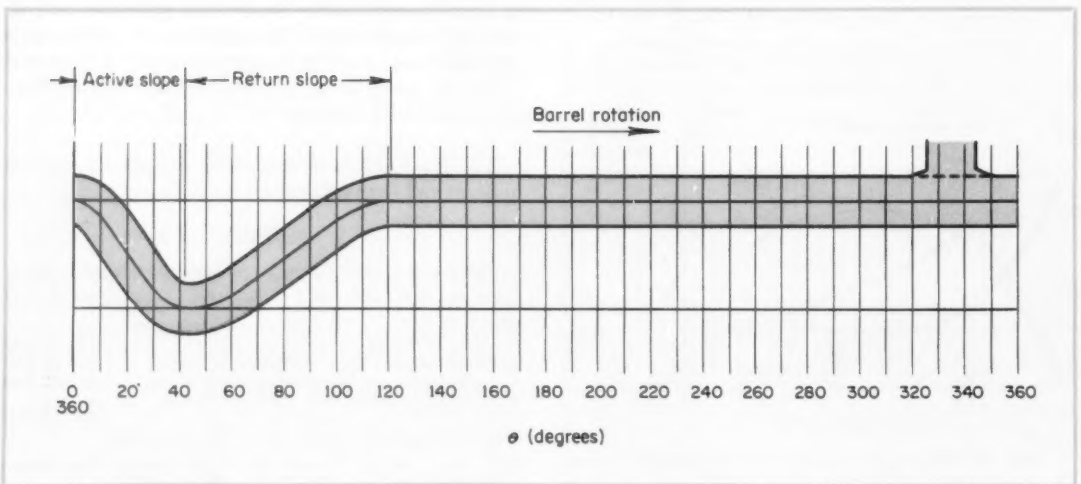
5. P. Bloch and R. C. Schneider—"Hydrodynamic Split-Torque Transmissions," SAE paper 92-W, Sept. 14, 1959.

Cylindrical Cam Furnishes Drive for

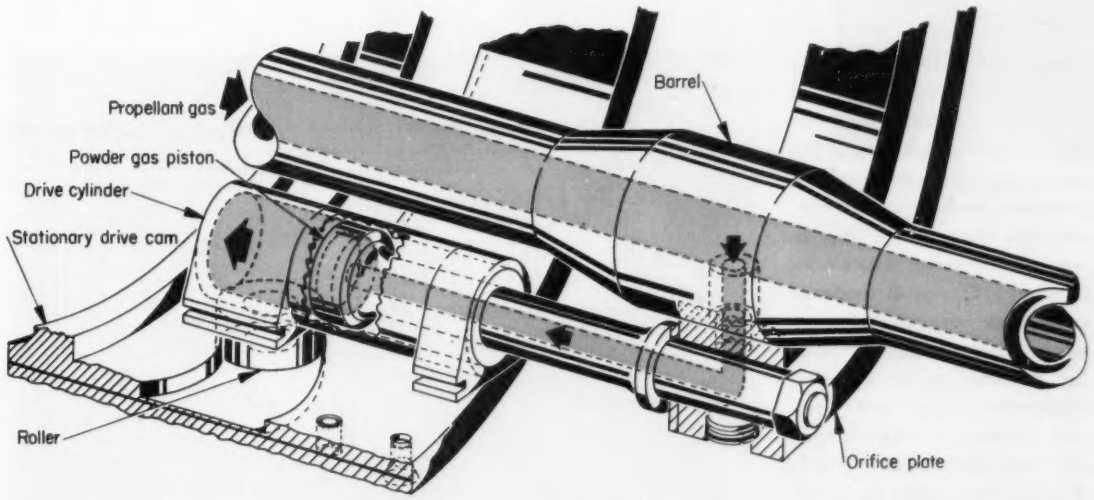


PROPELLANT GASES DRIVE rollers in the groove of a stationary cylindrical cam to keep a modern version of the Gatling gun rotating at constant speed without outside power. From a standstill the gun accelerates to a steady rate of 6000 shots per minute in 0.4 sec.

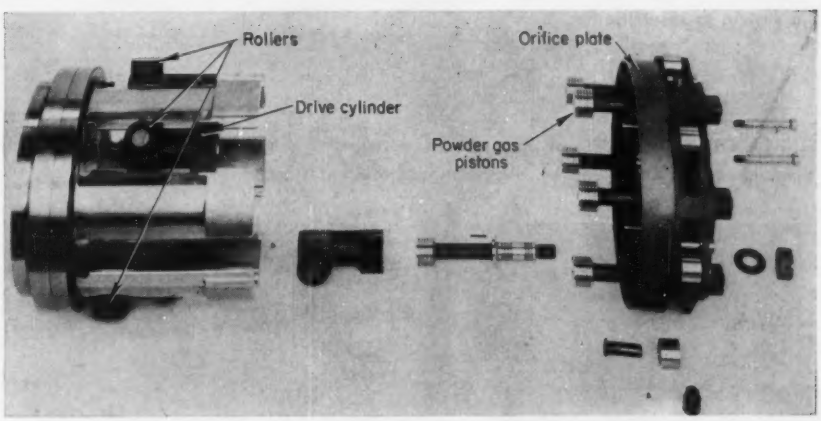
AUTOMATIC SPEED CONTROL is provided by the backslope of the cam curve. Acceleration of the gun occurs in the region from 0 to 40 degrees. As the speed of the gun increases, angular displacement during ignition delay increases. So the force on the roller is moved further down the active slope of the cam. More of the gas energy is dissipated on the cam return slope which tends to retard the speed of rotation. Return slope is designed to balance these forces as the gun approaches the desired steady rate of fire.



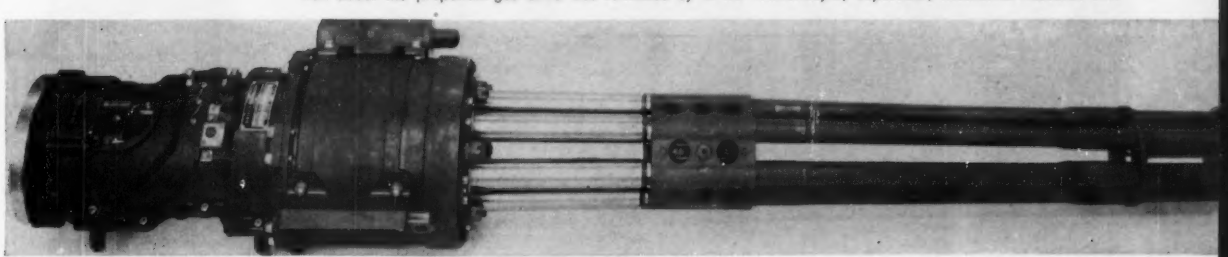
Modern Version of Gatling Gun



GAS IS BLED from the barrel of the fired gun through the center of a stationary powder-gas piston. The roller which rides in the groove of the cam is fastened to a moving cylinder that slides over the piston. Each barrel is equipped with separate piston, cylinder, and roller assembly.

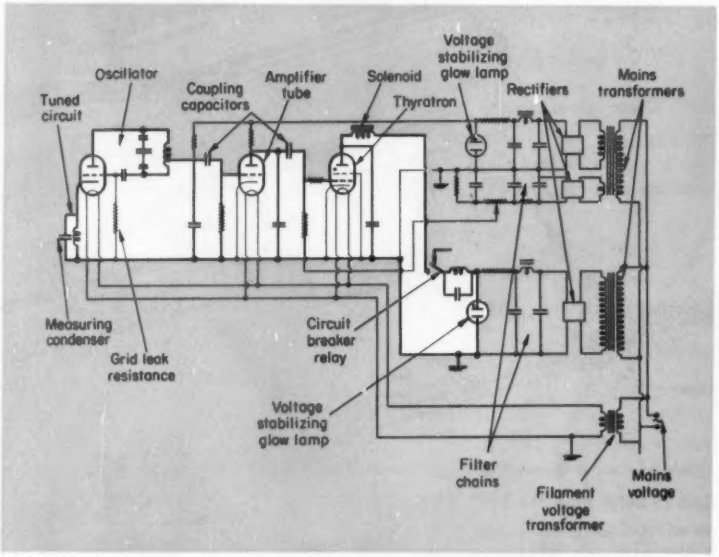


Multibarrel M61, called the Vulcan, was developed by the Springfield Armory and General Electric Corp. Cam-operated propellant-gas drive was developed for the Vulcan by Armour Research Foundation. Information about the propellant-gas drive was furnished by E. M. Wintermoyer, Supervisor, Mechanics Research Div.

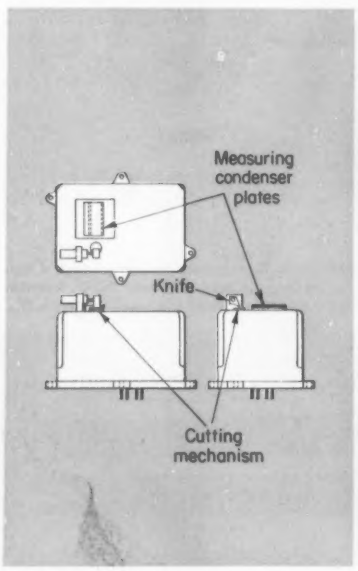


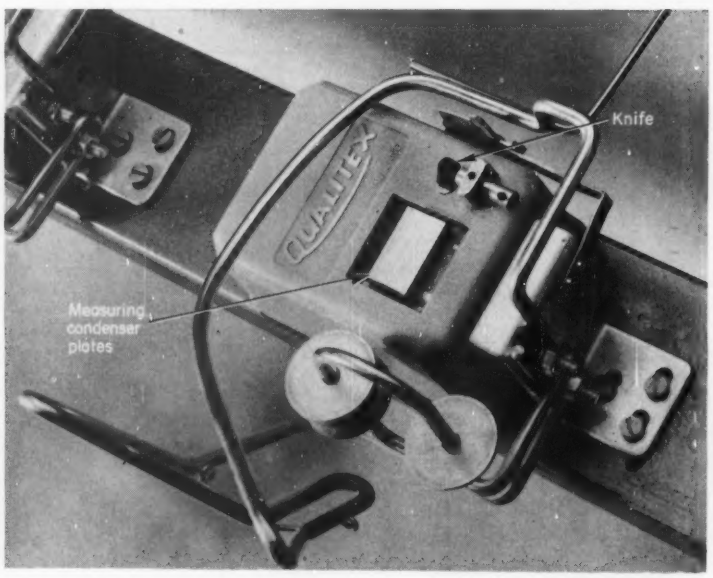
Condenser Replaces Photocell In Electronic Slubcatcher

CONDENSER PLATES DETECT slubs (thick spots in newly spun yarn) by change in capacitance as the yarn passes between them. This method replaces mechanical and pneumatic devices that put considerable strain on the yarn, as well as expensive photoelectric detectors. Change in condenser capacitance detunes a circuit which passes a signal through an amplifier to a thyratron. Augmented signal from thyratron actuates a solenoid-operated knife that cuts out the slub. After a 2-msec pause the circuit-breaker relay opens, allowing the system to reset itself.

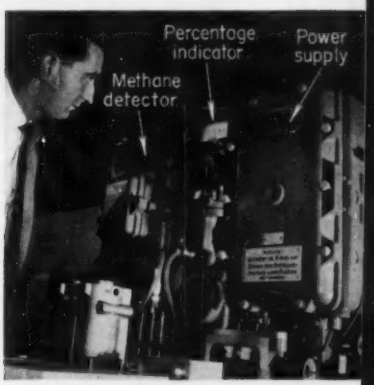


SLUBCATCHERS ARE USED at each spindle of winding and weaving machines. The condenser slubcatcher was developed by NV Electronische Apparatenfabriek Qualitex, Enschede, Holland.



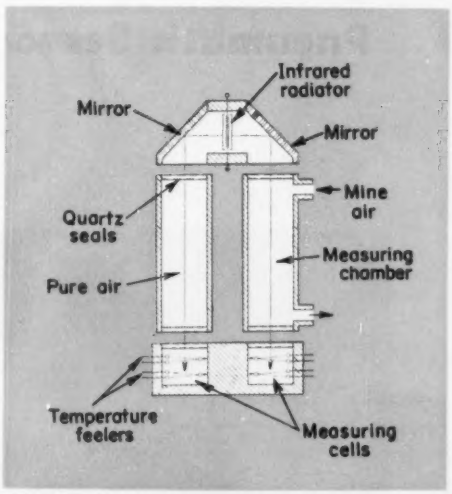


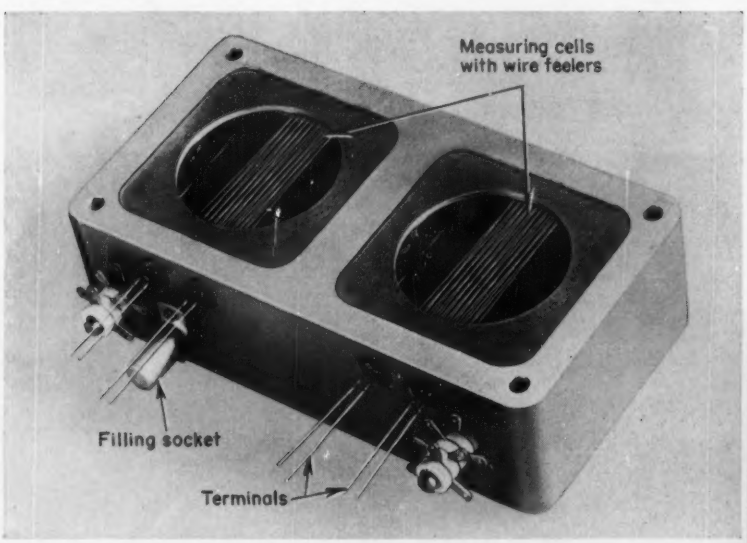
Meter Measures Methane Content in Mine Air By Checking Infrared Absorbtion



Methane meter is produced by Siemens & Halske AG, Karlsruhe, Germany.

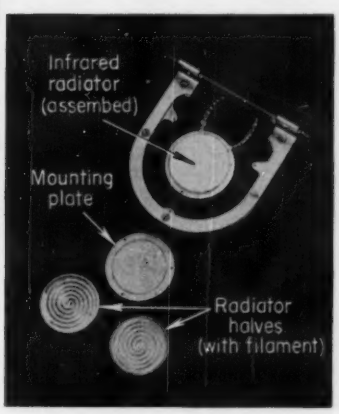
MINE AIR METER uses methane's characteristic absorption of infrared rays as a handy reference for checking against pure air: A continuous sample of mine air is drawn through a measuring chamber where its infrared transmissibility is checked against that of a pure air sample sealed in a similar chamber. Output of the instrument furnishes a running account of the methane level in the sampled air.

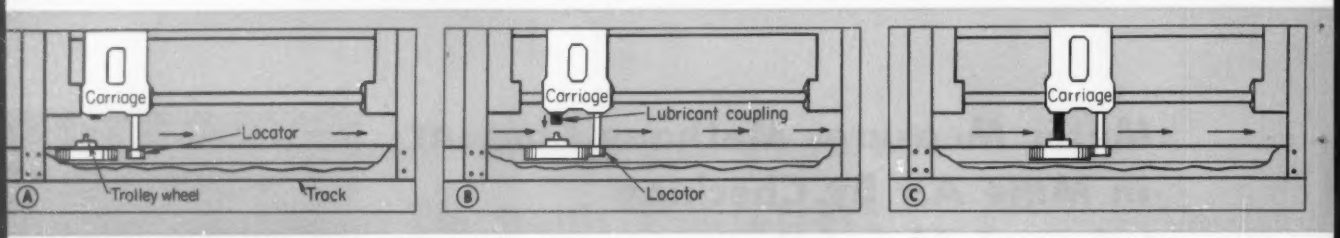




TRANSMITTED RADIATION IS TRAPPED in methane-filled cells where the corresponding rise in temperature changes the resistance of wire feelers. These feelers form two sides of a Wheatstone bridge. Potential across the bridge indicates amount of methane present. The potential is read off on a dial calibrated in percentage of methane present.

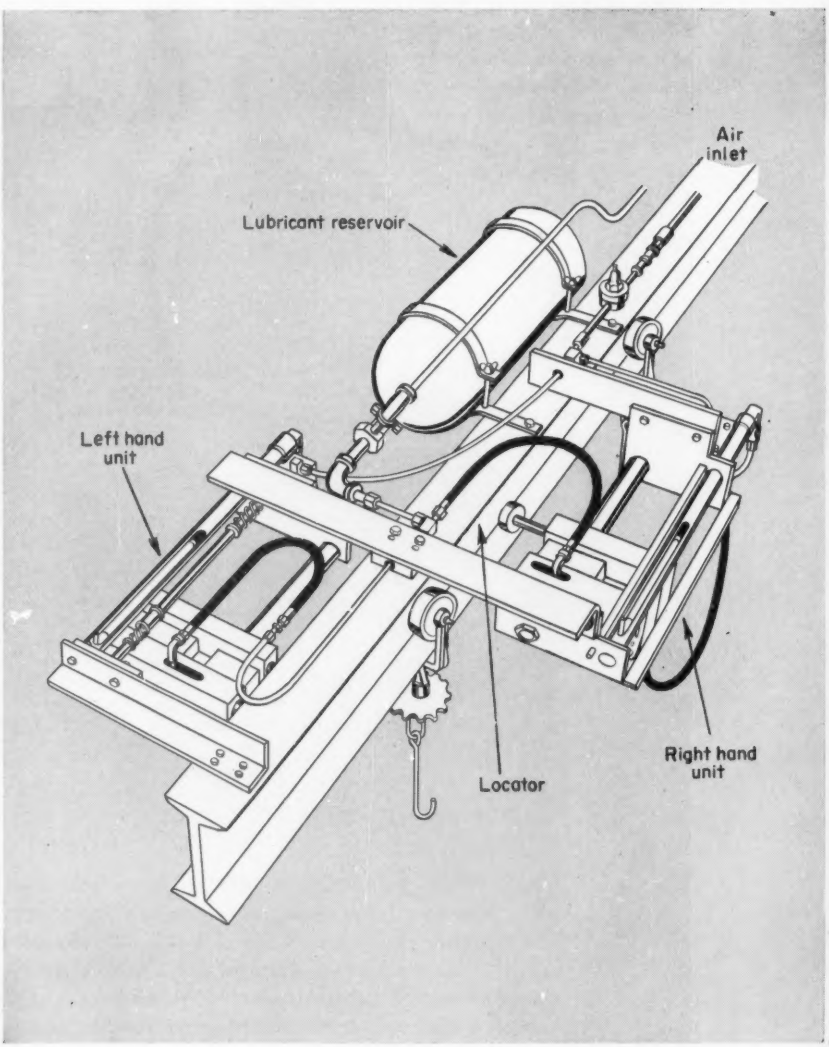
IDENTICAL RADIATION to the two chambers is produced by a filament protected by two ceramic radiator halves. Each chamber receives radiation from one surface of the resulting wafer-like radiator.



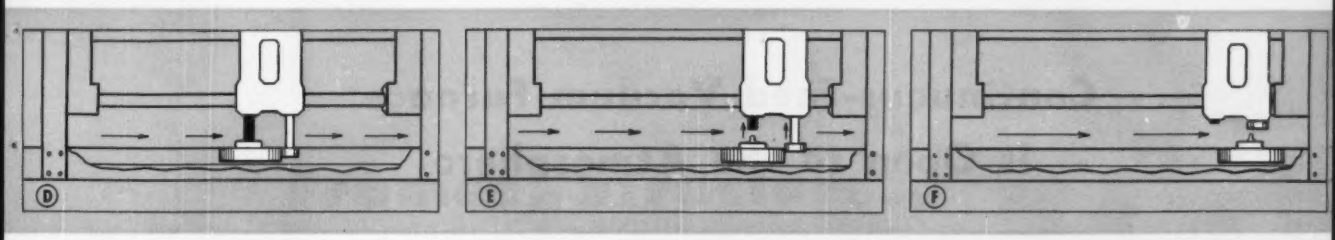


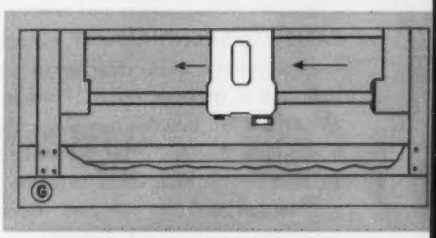
FLYING LUBE GUN delivers a measured squirt of lubricant to conveyor trolley wheels. The conveyor wheel contacts an overhung locator roller and pushes the lube carriage along its rails. As the carriage passes trip points, air valves are opened, causing the coupling to extend and engage the wheel's fitting; a measured amount of lubricant to be injected; and finally, the locator to retract permitting the wheel to pass and the carriage to return to its original position. Lube injector works only if coupling and fitting are properly engaged.

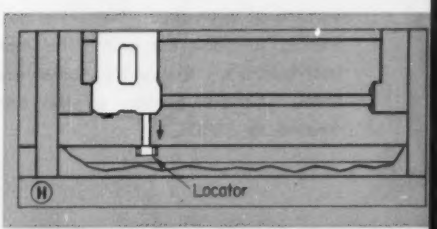
Pneumatic Servo Unit Lubricates



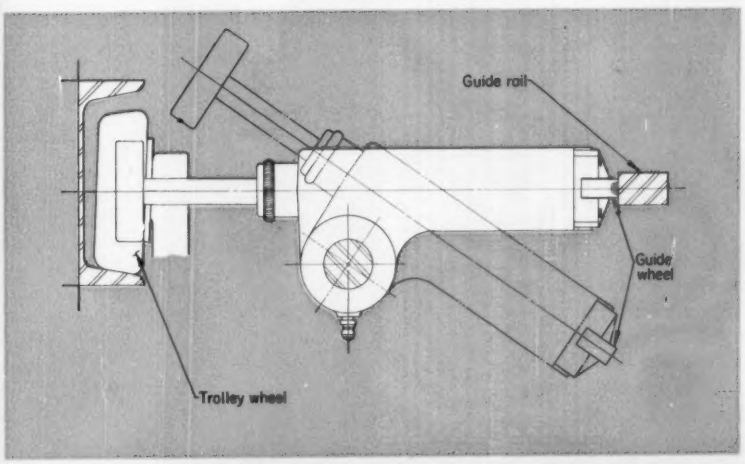
PACKAGED LUBRICATOR contains right and left hand carriage units and lubricant reservoir mounted on a 4-ft section of track. Customer cuts his track at a convenient spot and welds the unit in place.



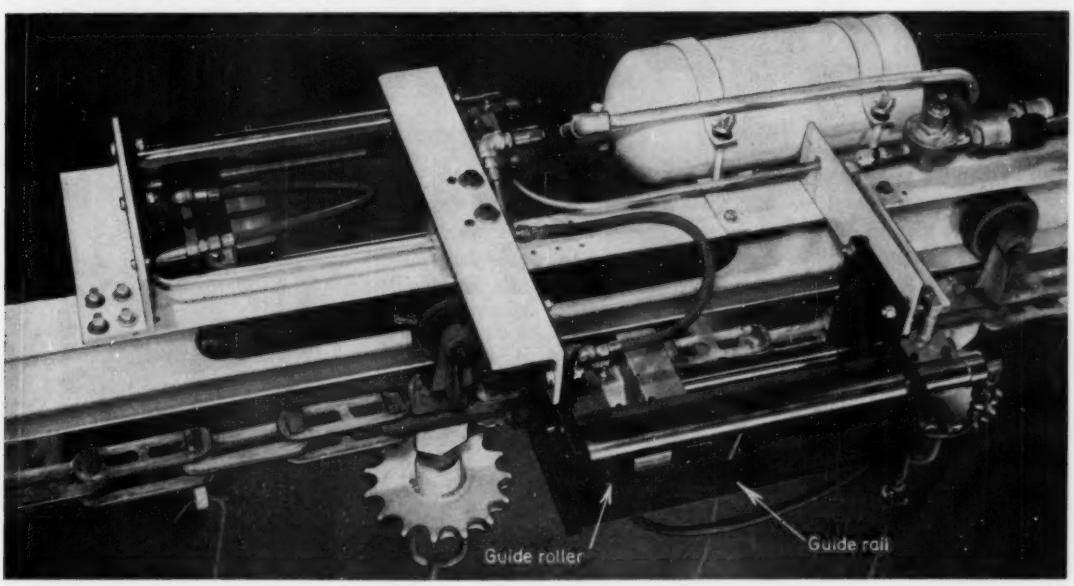




Trolley Wheels on the Move

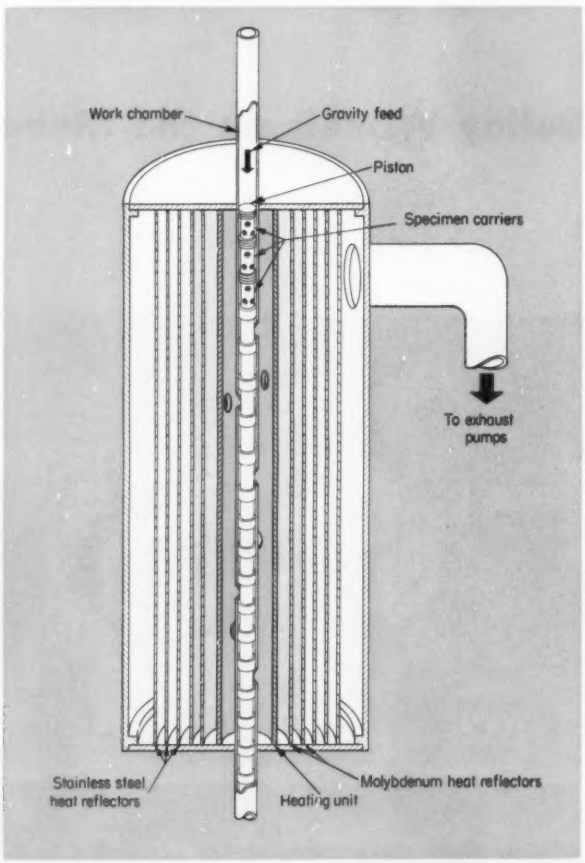


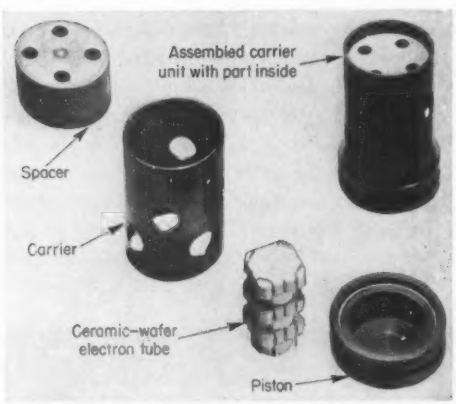
ROCKAWAY DESIGN PERMITS damaged wheels to pass without wrecking the lubricator. Occasionally a broken wheel will prevent the locator from retracting at the end of a cycle. Then the carriage progresses to a point where guide rails are notched and guide rollers can drop through. This allows the whole carriage to pivot about the main rail to lift the locator clear of the damaged wheel. Automatic lubricator was developed by Aro Equipment Corp., Bryan, O.



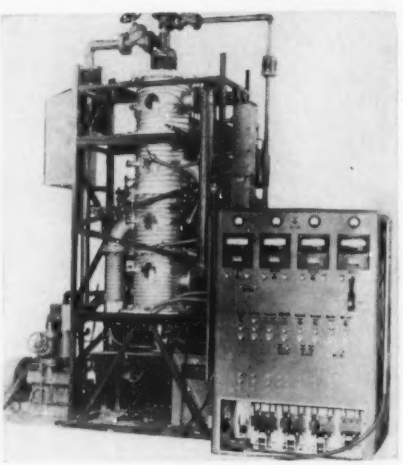
Continuous-Feed Vacuum Furnace Is Open to the Atmosphere

PARTS MOVE CONTINUOUSLY through a vacuum furnace whose work chamber is open to the atmosphere at both ends. Parts in a special carrier are fed into the top of the chamber and are pulled through it by the force of gravity. Exhaust pumps hold down pressure in the central section to 10^{-5} mm Hg. Heating unit is resistance wire supported on the grooved inner surface of a ceramic tube. Five heat-reflecting shields surround the unit. The inner two are molybdenum; the outer three are stainless steel. Central portion of the tube can be heated to 1000 C.





SHORT PISTONS SEAL OUT AIR as they ride between part carriers. Outside bearing surfaces of pistons are flame-coated with tungsten carbide. Very little air leaks past these pistons; most of the air pumped from the center of the furnace is desorbed from the parts being treated. Holes in carriers permit the escape of gas to evacuating system. Furnace was developed to evacuate and seal ceramic-wafer electron tubes.



ALL EQUIPMENT CAN BE FITTED into 15 sq ft of floor space. With carrier loading and unloading equipment, vertical requirement is 15 ft. The National Bureau of Standards developed the furnace for fabricating electronic components. Other uses might be vapor plating lenses or resistors, or production of vacuum condensers and switches. Lower end of tube can be lengthened and water cooled if product must emerge at or near room temperature.

Frames, Structures, and Spring-Mounted Beams

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RECEPTANCE or displacement-mobility methods are convenient for analyzing steady-state vibration of frames or structures. Although the subsystem arrangement is angular, techniques of problem solution are similar to those discussed for stepped beams.[6]

For beams which are mounted on flexible supports, the impedance matching concept is most applicable. Impedance matching was previously introduced as a means for determining natural frequencies of complex systems.[5]

Simplified procedures for vibration analysis of both frames and spring-mounted beams are demonstrated here.

Frames and Structures

The method used previously[6] for stepped beams can be extended to frames.[7] The chief difference is that subsystems for frames are at an angle with each other while beam subsystems are in a straight line. Two examples illustrate application of the procedures to frames.

Example 1: A horizontal harmonic force, F_e, is applied to the tip of a bent cantilever, Fig. 36*a*. This cantilever can be broken into the two subsystems, *A* and *B*, Fig. 36*b*. Subsystem *A* corresponds to a clamped-free beam with internal force F_a and internal moment T_a acting at the free end.

The vertical leg, subsystem *B*, corresponds to a free-pinned beam with external harmonic force F_e

*References are tabulated at end of article.

acting at the free end. The lower end of this beam can move in a vertical direction but is pinned with respect to horizontal motion by the horizontal leg, subsystem A. Thus, motion is limited to small amplitudes. Internal force F_b and internal moment T_b act upon the lower end of subsystem B.

If receptances of subsystem A are designated by α and those of subsystem B by β, then

$$\theta_{EB} = \beta_1 F_e + \beta_2 T_b \tag{105}$$

$$\theta_{EA} = \alpha_1 T_a + \alpha_2 F_a \tag{106}$$

$$y_{EB} = \beta_3 F_b \tag{107}$$

$$y_{EA} = \alpha_3 T_a + \alpha_4 F_a \tag{108}$$

$$T_a + T_b = 0 \tag{109}$$

$$F_a + F_b = 0 \tag{110}$$

$$\theta_{EA} = \theta_{EB} \tag{111}$$

$$y_{EA} = y_{EB} \tag{112}$$

To make the problem more general, assume that the two legs of the cantilever are made of different materials and have different cross-sectional dimensions. Thus, beam frequency factors λ_A and λ_B are:

$$\lambda_A = \left(\frac{\omega^2 A_A \rho_A}{E_A I_A} \right)^{1/4}$$

$$\lambda_B = \left(\frac{\omega^2 A_B \rho_B}{E_B I_B} \right)^{1/4}$$

Values of the displacement mobilities or receptances can be calculated from the equations in Table 10.[6] For subsystem A, the clamped-free beam,

$$\alpha_1 = \frac{\theta_{EA}}{T_a} = \alpha_{L'L'} = \frac{N_6}{E_A I_A \lambda_A N_4}$$

$$\alpha_2 = \frac{\theta_{EA}}{F_a} = \alpha_{L'L} = \frac{N_1}{E_A I_A \lambda_A^2 N_4}$$

$$\alpha_3 = \frac{y_{EA}}{T_a} = \alpha_{LL'} = \alpha_2$$

$$\alpha_4 = \frac{y_{EA}}{F_a} = \alpha_{LL} = \frac{-N_5}{E_A I_A \lambda_A^3 N_4}$$

For subsystem B, the free-pinned beam,

$$\beta_1 = \frac{\theta_{EB}}{F_e} = \alpha_{L'o} = \frac{-N_7}{E_B I_B \lambda_B^2 N_5}$$

$$\beta_2 = \frac{\theta_{EB}}{T_b} = \alpha_{L'L'} = \frac{N_4}{E_B I_B \lambda_B N_5}$$

and, from Equation 13,[1]

$$\beta_3 = \frac{y_{EB}}{F_b} = -\frac{1}{m_B \omega^2}$$

When dimensions of the two legs and impressed frequency ω are known, values of λ_A and λ_B can be determined. Then, after the values of N are determined from the equations in Table 11,[6] numerical values of the receptances can be calculated. The values of α and β can now be substituted in Equations 105 through 108, along with the relationships given by Equations 109 to 112, to find F_a, F_b, T_a, T_b, θ_E and y_E.

Equations 105 to 112 may also be used to find the natural frequencies of the cantilever by setting the impressed force, F_e, equal to zero. These equations are then solved to give

$$(\alpha_1 + \beta_2)(\alpha_4 + \beta_3) - \alpha_2 \alpha_3 = 0 \tag{113}$$

which becomes, by substitution,

$$\left(\frac{N_6}{E_A I_A \lambda_A N_4} + \frac{N_4}{E_B I_B \lambda_B N_5} \right) \times \left(\frac{-N_5}{E_A I_A \lambda_A^3 N_4} - \frac{1}{m_B \omega^2} \right) - \left(\frac{N_1}{E_A I_A \lambda_A^2 N_4} \right)^2 = 0$$

Values of ω which satisfy Equation 113 are the natural frequencies of the bent cantilever and may be found by plotting the value of Equation 113 versus assumed values of ω. Each point where the

Nomenclature

A = Area, sq in.
E = Young's modulus of elasticity, psi
F = Force, lb
f = Cyclic frequency, cps
g = Acceleration of gravity, in. per sec per sec
I = Sectional moment of inertia, in.^{4}
J = Mass moment of inertia, in.-lb-sec^2
j = Imaginary operator $= (-1)^{1/2}$
k = Spring gradient or rate, lb per in.
L = Length of beam, in.
M_V = Velocity mobility, in. per lb-sec
m = Mass, lb-sec^2 per in.
N = Beam factor (Table 11[6])
T = Moment, lb-in.
t = Time, sec
v = Velocity, in. per sec
x = Distance measured along the beam, in.
y = Transverse displacement, in.
Z = Impedance
Z_V = Velocity impedance, lb-sec per in.
α, β, γ = Receptances
θ = Slope, rad
λ = Beam frequency factor (Equation 82[6])
μ = Mass density per inch of beam length, lb-sec^2 per in.^{2}
ρ = Mass density, lb-sec^2 per in.^{4}
ω = Circular or angular frequency, rad per sec

Subscripts

A, B, C = Subsystems
e = Point of applied excitation
i = Mode number; effective value at mode number
J = Rocking mode
m = Mass
n = Natural or resonant
o = Characteristic
s = Spring

curve crosses the zero axis represents one of the natural frequencies of the system.

This method of analysis has been verified experimentally for a specific frame system.[7]

Example 2: Consider the portal frame, Fig. 37*a*, which is subjected to an external impressed horizontal harmonic force, $F_e \sin \omega t$. This system may be broken into three subsystems, *A*, *B*, and *C*, Fig. 37*b*. Internal excitations *T* and *F* act between the various subsystems or legs in addition to external excitation F_e which acts on leg *A*. Legs *A* and *C* are clamped-free beams, while leg *B* is a pinned-pinned beam which is free to translate axially.

As in Example 1, a set of equations may be developed for the system, using α, β, and γ to identify receptances of the individual subsystems:

$$y_{RA} = y_{RB} \tag{114}$$

$$y_{SB} = y_{SC} \tag{115}$$

$$\theta_{RA} = \theta_{RB} \tag{116}$$

$$\theta_{SB} = \theta_{SC} \tag{117}$$

$$T_a + T_{b1} = 0 \tag{118}$$

$$F_a + F_{b1} = 0 \tag{119}$$

$$T_{b2} + T_c = 0 \tag{120}$$

$$F_{b2} + F_c = 0 \tag{121}$$

$$\theta_{RA} = \alpha_1 F_e + \alpha_2 F_a + \alpha_3 T_a \tag{122}$$

$$y_{RA} = \alpha_4 F_e + \alpha_5 F_a + \alpha_6 T_a \tag{123}$$

$$\theta_{RB} = \beta_1 T_{b1} + \beta_2 F_{b1} + \beta_3 T_{b2} + \beta_4 F_{b2} \tag{124}$$

$$y_{RB} = \beta_5 T_{b1} + \beta_6 F_{b1} + \beta_7 T_{b2} + \beta_8 F_{b2} \tag{125}$$

$$\theta_{SB} = \beta_9 T_{b1} + \beta_{10} F_{b1} + \beta_{11} T_{b2} + \beta_{12} F_{b2} \tag{126}$$

$$y_{SB} = \beta_{13} T_{b1} + \beta_{14} F_{b1} + \beta_{15} T_{b2} + \beta_{16} F_{b2} \tag{127}$$

$$\theta_{SC} = \gamma_1 T_c + \gamma_2 F_c \tag{128}$$

$$y_{SC} = \gamma_3 T_c + \gamma_4 F_c \tag{129}$$

Values of receptances α, β, and γ can be found by the same method used in Example 1. Equations

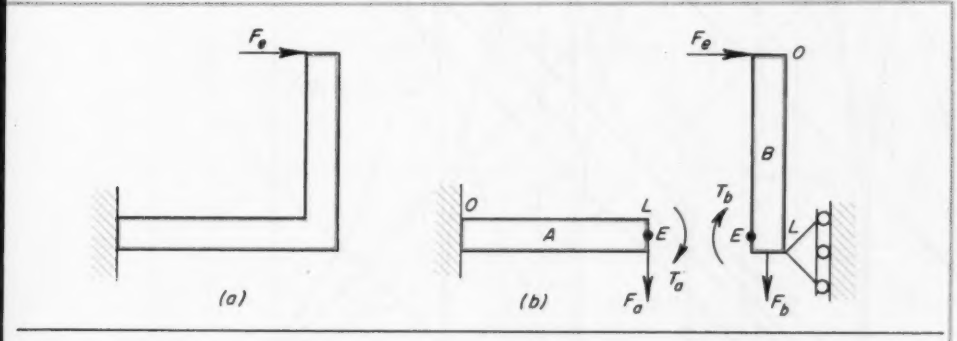


Fig. 36 — Bent cantilever beam with harmonic force applied at tip of beam. Complete system is shown at *a*, subsystem breakdown at *b*.

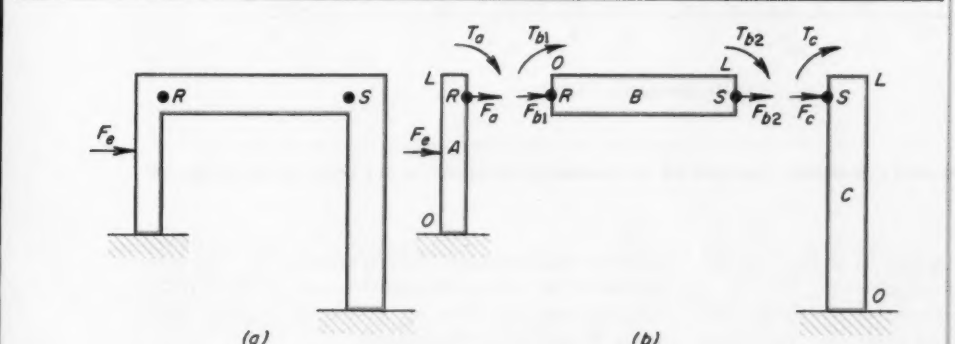


Fig. 37 — Portal frame with harmonic force applied at one vertical member. Complete system is shown at *a*, subsystem breakdown at *b*.

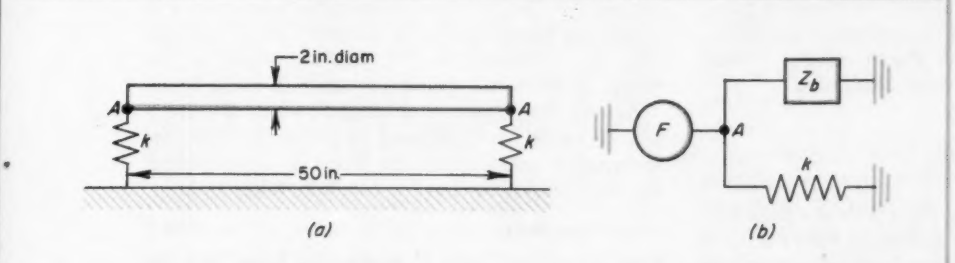


Fig. 38—Uniform-section beam supported on springs of adjustable gradient. Conventional representation of complete system is shown at *a*. Schematic mobility diagram for subsystem breakdown is shown at *b*.

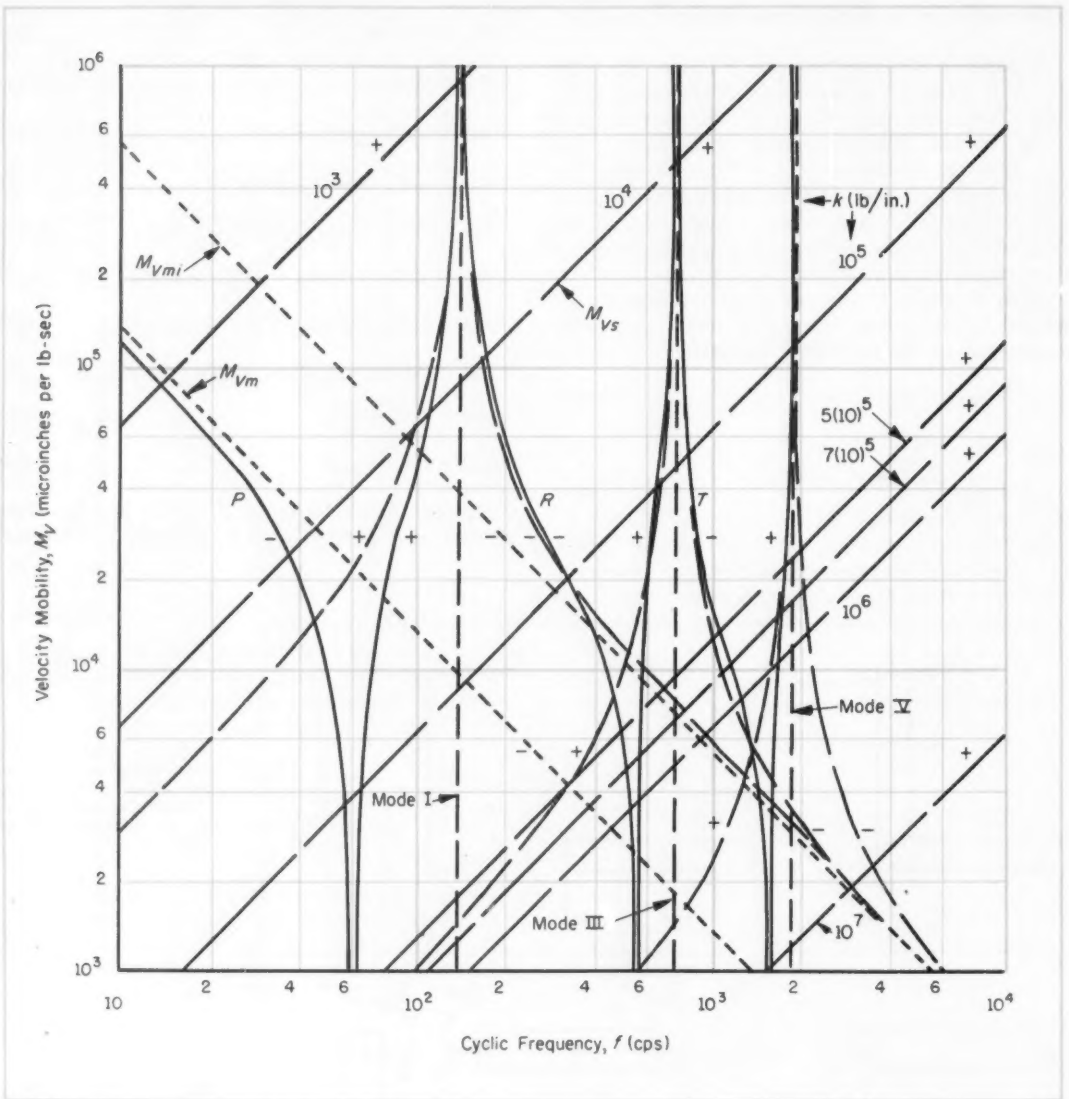


Fig. 39—Velocity-mobility spectrum of the symmetric normal modes for beam system of Fig. 38.

114 through 129 are then solved to determine the responses and reactions at points R and S, Fig. 37.

To find the natural frequencies of the entire system, set F_e equal to zero and determine the value of ω that will satisfy Equations 114 and 129.

Another procedure for analyzing structures is given in the literature.[8] Based on normal-mode mobilities, it deals with the problem of discrete masses located on a frame with motion in three directions.

Spring-Mounted Beams

The impedance matching concept is a convenient means for determining the deflection response of a uniform-section beam supported on springs whose stiffness can be varied. Such a system, Fig. 38*a*, may be excited at various frequencies, ω or f. This system will be analyzed here on a velocity-mobility basis using the normal-mode method.

Analysis is facilitated by dividing the complete system, Fig. 38*a*, into two subsystems: Subsystem b is a free-free beam; subsystem s consists of the springs. The two subsystems in Fig. 38*a* are joined at two points, A, where the springs are attached to the beam.

Assume that an external force, F, whose frequency can be varied, is introduced at points A. Since the springs are attached to the beam at these points, the two subsystems have a common velocity, or

$$v_{As} = v_{Ab} = v_A \qquad (130)$$

Part of external force F excites the beam and the

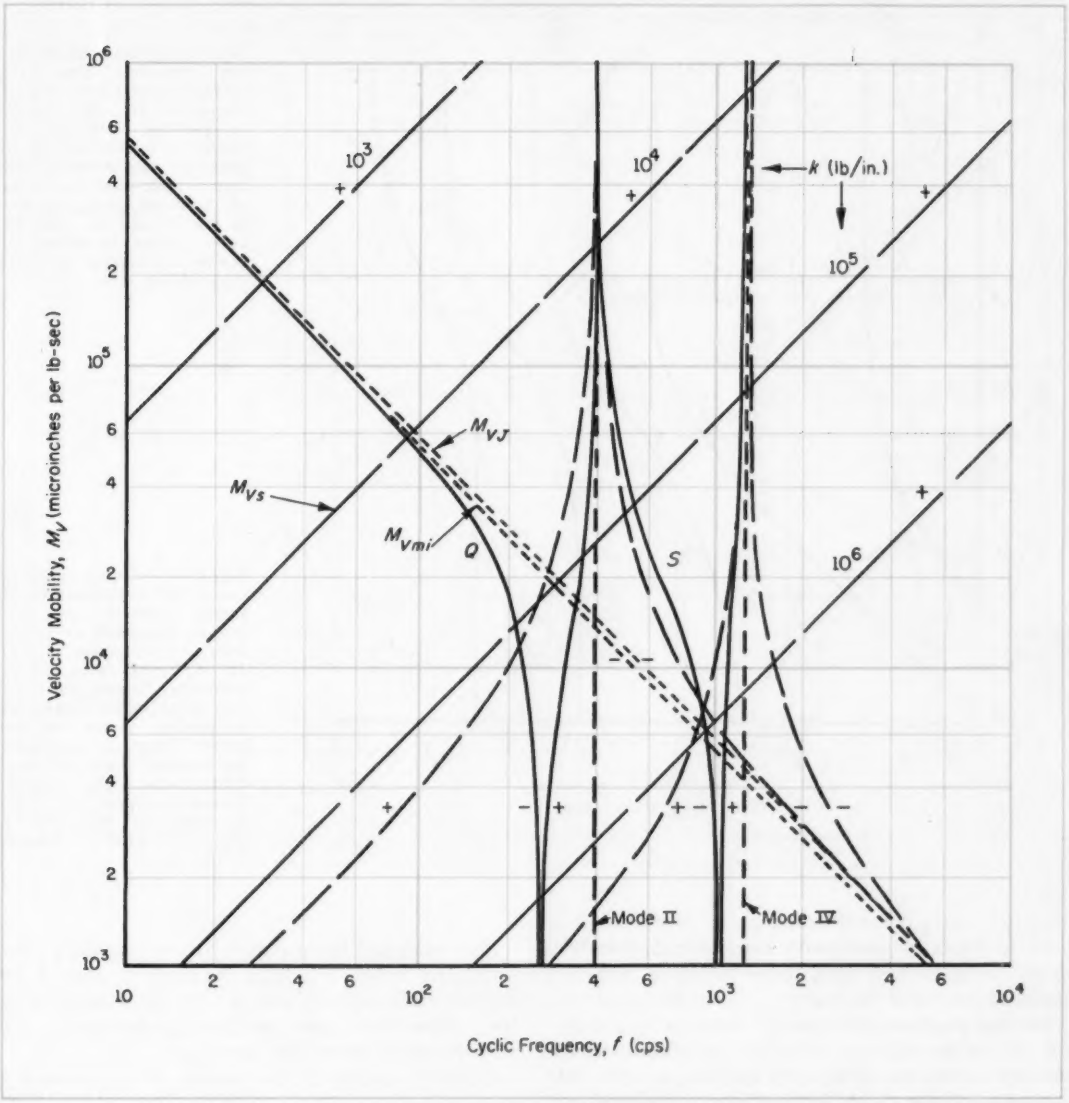


Fig. 40—Velocity-mobility spectrum of the antisymmetric normal modes for beam system of Fig. 38.

remainder excites the springs, or

$$F = F_a + F_b \qquad (131)$$

The subsystems act in parallel as shown in Fig. 38*b*.

Deflection response of the beam at any impressed frequency is made up of components determined by the normal-mode shapes plus the inertia of the beam itself. Inertia of the beam depends on the type of mode shape. If the mode shape is symmetrical about the center of gravity or midpoint of the beam (Modes I, III, and V of Table 12[6]), inertia of the beam is a function of its total mass.

For antisymmetric modes (Modes II and IV of Table 12[6]), a rocking action occurs. In this case, inertia of the beam is a function not only of its total mass but also of its mass moment of inertia about the midpoint.

Thus, the two types of mode shapes must be dealt with separately. The symmetric normal modes, Fig. 39, will be considered in detail first. Then, the antisymmetric case, Fig. 40, will be discussed.

The procedure is illustrated using a steel beam with a total weight of 44.5 lb or a total mass of 0.115 lb-sec^2 per in. The mass moment of inertia about the center of gravity or midpoint of the beam is 24 in.-lb-sec.^{2}

Symmetrical Mode Shapes: Calculated values of natural frequencies and effective masses for this free-free beam are given in Table 14 for the first five normal modes of vibration. Values of ϕ_i can be calculated by methods outlined previously.[6] The values

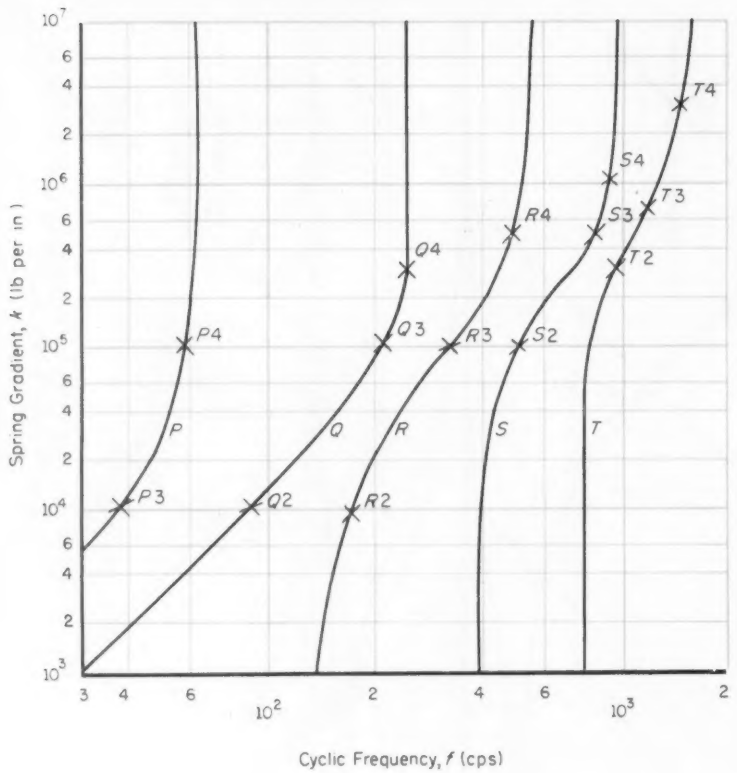


Fig. 41—Spring gradient versus frequency plots for spring-mounted beam system shown in Fig. 38. Points for plotting curves are obtained at frequencies where positive spring-mobility lines intersect the negative curves of combined beam mobility in Fig. 39 and 40. Specific curve points identified by crosses correspond to portions of Fig. 42.

Fig. 42—Deflection response curves for combinations of spring gradient and impressed frequency at points selected from curves in Fig. 41. Columns correspond to individual curve plots in Fig. 41 and rows correspond to specific points on the curves. Row 1 represents the free-free beam end condition, row 5 the pinned-pinned condition. Scale relationships are indicated by the curve plot in column *P* row 1.

given in Table 14 were taken from general tables[9,10] for a free-free beam with force excitation and response at the end of the beam.

Driving-point mobility of the beam at point *A*, Fig. 38, is the algebraic sum of the effective-mass mobility of the free-free beam and the mobility of the mass of the beam itself. Velocity mobility of the mass of the beam is, from Equation 10,[1]

$$M_{Vm} = -\frac{j}{m\omega} = -\frac{j}{0.115\omega}$$

Velocity mobility of the effective mass for each normal mode is

$$M_{Vmi} = -\frac{j}{0.02875\omega}$$

These mobilities are plotted as straight, slanting lines (short dash) in Fig. 39. Vertical natural-frequency lines for normal modes I, III, and V are located by the values given in Table 14. The intersection of the effective-mass mobility line with the natural-frequency lines locates the characteristic mobilities (M_{Vo}). These characteristic mobilities, in turn, are used to locate the template positions for the beam normal-mode mobility curves (long dash) for each mode.

The combined beam-mobility curve (solid) for the symmetric modes, Fig. 39, is the algebraic sum of the normal-mode mobility curves and the mass-mobility line. Note that some portions of this curve are positive while others are negative.

Velocity mobility of the springs is (Equation 9[1])

$$M_{Vs} = \frac{j\omega}{k}$$

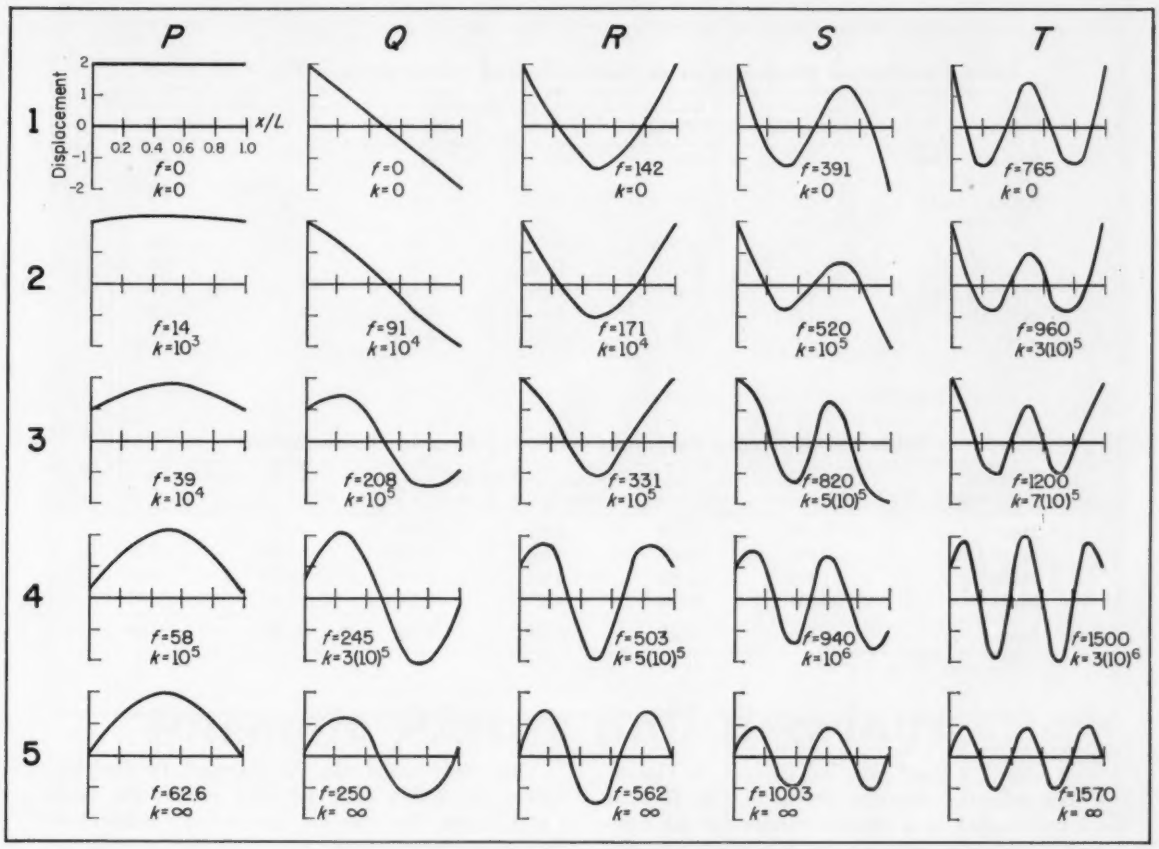
In Fig. 39, several spring-mobility lines (long dash) are plotted for different values of k.

Earlier, it was assumed that an external force, F, is applied at points *A*, Fig. 38. Actually, no such force is applied, and Equation 131 should be

Table 14—Values of Natural Frequency and Effective Mass for Beam in Example 2

Mode Number	f_n (cps)	ϕ_i $(x/L = 0)$*	$m_i = \mu L/[\phi_i^2(0)]$
I	142	2	0.02875
II	391	2	0.02875
III	765	2	0.02875
IV	1268	2	0.02875
V	1890	2	0.02875

*From Reference 9 or 10.



$$F_a + F_b = 0$$

If this relationship is divided by v_A (Equation 130),

$$Z_{Va} + Z_{Vb} = 0 \tag{132}$$

or

$$\frac{1}{M_{Va}} + \frac{1}{M_{Vb}} = 0 \tag{133}$$

Whenever a spring-mobility line, which is always positive, crosses a negative, combined beam-mobility curve, Fig. 39, Equations 132 and 133 are satisfied. Points where these intersections occur can be used to plot curves of spring stiffness versus frequency. Curves *P*, *R*, and *T* in Fig. 41 were obtained in this manner.

Resultant velocity response for any frequency is

$$v_A = v_{Am} + v_{AI} + v_{AIII} + v_{AV} + \ldots \tag{134}$$

Thus, the resultant velocity response consists of the velocity of the beam mass plus the velocities corresponding to the odd-numbered normal modes. The mass mobility and the various normal-mode mobilities each represent a certain per cent of the resultant mobility. These same percentage relationships exist for each of the corresponding mass and normal-mode velocity conditions that determine the shape of the resultant velocity or deflection curve of the beam at a particular frequency and support stiffness. Since frequency is fixed for a given case, deflection response equals velocity response divided by circular frequency ω.

The displacement normal-mode shapes for various x/L positions along the beam are tabulated in both Reference 9 and 10. Values that apply to the free-free beam arrangement in this example are given in Table 15 in abbreviated form.

The procedure for obtaining the deflection-response curve for a combination of given spring stiffness and impressed frequency will be illustrated for a point on curve *T*, Fig. 41, where $k = 7(10)^5$ lb per in. In Fig. 39, note that the spring-mobility line for a spring gradient of $7(10)^5$ lb per in. intersects the negative combined-mobility curve at a frequency of 1200 cps. Combined beam mobility at this point is $-10{,}570$ microinches per lb. The individual mobilities, their value, and their percentage of the resultant or combined value are, respectively: Mass, -1170, $+11.05$ per cent; Mode I, -4700, $+44.5$ per cent; Mode III, -7900, $+74.75$ per cent; Mode V + 3200, -30.3 per cent. The mode-shape displacements of Table 15 are then multiplied by the corresponding mobility percentages (expressed as decimals) and totaled to obtain the resultant response. These values are given in Table 16. The sums are plotted against

Table 15—Normal Mode Shapes at Equally-Spaced Points along a Free-Free Beam

Mode Shape	Displacement					
	$x/L = 0$	$x/L = 0.2$	$x/L = 0.4$	$x/L = 0.6$	$x/L = 0.8$	$x/L = 1.0$
Bouncing mode for mass	2.0	2.0	2.0	2.0	2.0	2.0
Rocking mode for mass	2.0	1.2	0.4	−0.4	−1.2	−2.0
Mode I	2.0	0.1955	−1.040	−1.040	0.1955	2.0
Mode II	2.0	−0.795	−0.966	0.966	0.795	−2.0
Mode III	2.0	−1.286	0.656	0.656	−1.286	2.0
Mode IV	2.0	−1.2	1.4	−1.4	1.2	−2.0
Mode V	2.0	−0.611	0.2223	0.2223	−0.611	2.0

Table 16—Deflection Responses for Spring-Mounted Beam System*

Response Component	Deflection					
	$x/L = 0$	$x/L = 0.2$	$x/L = 0.4$	$x/L = 0.6$	$x/L = 0.8$	$x/L = 1.0$
Mass	0.221	0.221	0.221	0.221	0.221	0.221
Mode I	0.890	0.087	−0.463	−0.463	0.087	0.890
Mode III	1.496	−0.960	0.491	0.491	−0.960	1.496
Mode V	−0.605	0.185	−0.067	−0.067	0.185	−0.605
Sum	2.000	−0.467	0.182	0.182	−0.467	2.000

*For case *T*3 in Fig. 42

x/L as Case *T*3, third row, last column, in Fig. 42.

Other deflection-response curves in Fig. 42 have been constructed in a similar manner for the combinations of spring gradient and impressed frequency indicated by crosses on the curves of Fig. 41. The symbols which identify the curve points in Fig. 41 correspond to columns and rows in Fig. 42.

When $k = 0$, which corresponds to the top row in Fig. 42, mode shapes are the pure, normal-mode shapes for a free-free beam. Also, the frequencies correspond to natural frequencies for this case of a free-free beam. When $k = \infty$, which corresponds to the bottom row of Fig. 42, mode shapes are again pure normal ones and frequencies correspond to the natural frequencies of pinned-pinned beams. Row-to-row sequence of curve plots in each column in Fig. 42 provides an effective picture of the gradual transition of mode shapes as the beam changes from the free-free to the pinned-pinned condition.

Antisymmetrical Mode Shapes: The procedure for finding the antisymmetrical deflection responses is similar to the one just outlined for symmetrical modes. The process is illustrated in Figs. 40, 41, and 42 by the curve plots for even-numbered modes. Velocity mobility for the rocking mode is

$$M_{VJ} = \frac{1}{m\omega} + \frac{(L/2)^2}{J_G\omega} = \frac{1}{0.115\omega} + \frac{(25)^2}{24\omega} = \frac{5.54}{f}$$

where J_G is mass moment of inertia about the center of gravity of the beam. The normal modes are II and IV, and the mode shapes may again be taken from Table 15.

This study could also be extended to situations where the spring rates for each end of the beam are different. For example, one end of a beam could be spring-supported and the other end pinned, etc.

References

This article is the seventh and concluding part in a series by Austin H. Church on simplified vibration analysis. Previous articles and issues of Machine Design in which they appeared are:

1. "Mobility and Impedance Concepts" ..... February 18, 1960
2. "Single-Degree-of-Freedom Systems" ..... March 3, 1960
3. "Two-Degree-of-Freedom Systems" ..... March 17, 1960
4. "Lumped Multiple-Mass Systems" ..... March 31, 1960
5. "Combination of Subsystems" ..... April 14, 1960
6. "Beams" ..... April 28, 1960

Other references in this article are:

7. R. E. D. Bishop—"The Vibration of Frames," *Proc. of the Inst. of Mech. Engr.* (British), Vol. 170, 1956, pp. 955-968.
8. *Mechanical Impedance Methods for Mechanical Vibrations,* edited by R. Plunkett, ASME, 1958, pp. 77-86.
9. D. Young and R. P. Felgar—*Tables of Characteristic Functions of a Beam,* Engineering Research Series, No. 44, University of Texas, 1949.
10. R. E. D. Bishop and D. C. Johnson—*Vibration Analysis Tables,* Cambridge University Press, New York, 1956.

Extra Copies

Copies of the entire series by Austin H. Church along with the two-part series (December 10 and 24 issues) by Richard P. Thorn, are available as a single bound pamphlet, "Simplified Vibration Analysis by Mobility and Impedance Methods," for $2.00 each from: Reader Service Dept., Machine Design, Penton Bldg., Cleveland 13, Ohio.

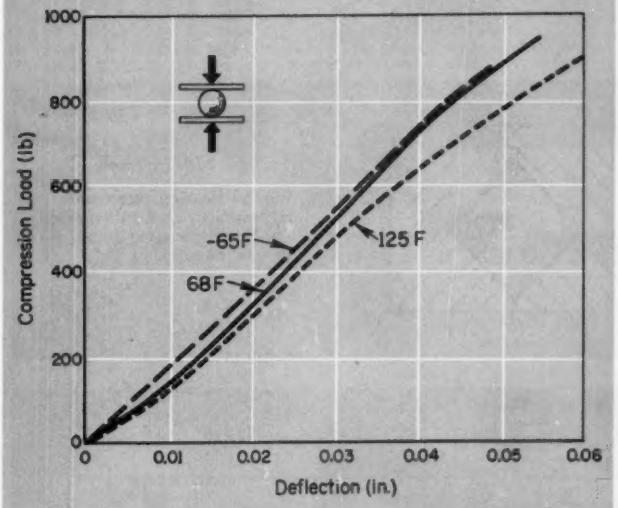


Fig. 1—Deflection versus compression load on 0.4063 in. diam phenolic balls.

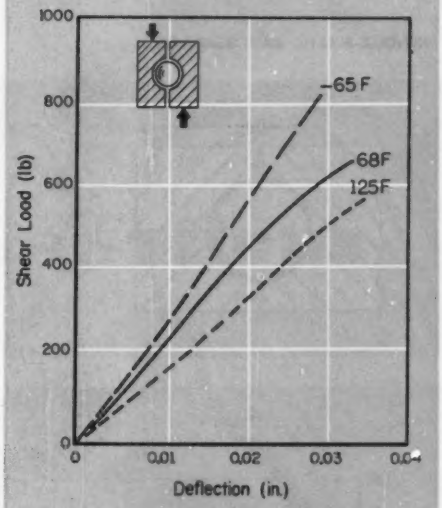


Fig. 2—Deflection versus shear load on 0.4063 in. diam phenolic balls.

Phenolic-Plastic Ball Bearings

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and

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PLASTIC balls in large-size bearings offer promise of good performance. Assemblies are economical, lightweight, and corrosion and shock-resistant. Physical characteristics of individual phenolic balls and of full assemblies have been evaluated under simulated load and shock conditions. The balls, available commercially, were centerless-ground from cast-phenolic bars. A previous article* covered similar data on melamine balls.

Individual Ball Tests: Elastic limit tests on 0.4063 ± 0.0005 in. diam load-carrying balls show that a permanent set of 0.0005 in. is produced by a 250-lb load between flat plates. Test loads up to 200 lb cause no permanent set, although the balls do not return immediately to their original dimensions.

Compression and shear loads at several temperatures are plotted against ball deflection in Fig. 1 and 2.

Bearing Assembly Performance: Test assemblies were 10 in. pitch-diameter bearings. Evaluations are

*Joseph E. Montalbano—"Plastic Ball and Roller Bearings," MACHINE DESIGN, Vol. 30, No. 16, August 7, 1958, pp. 96-99.

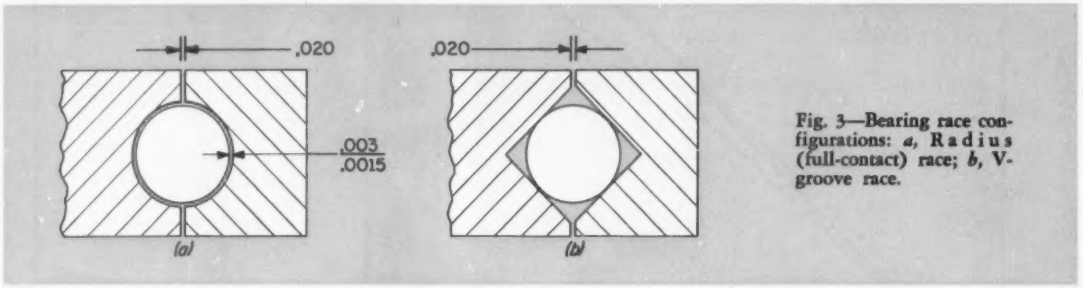

Fig. 3—Bearing race configurations: *a*, Radius (full-contact) race; *b*, V-groove race.

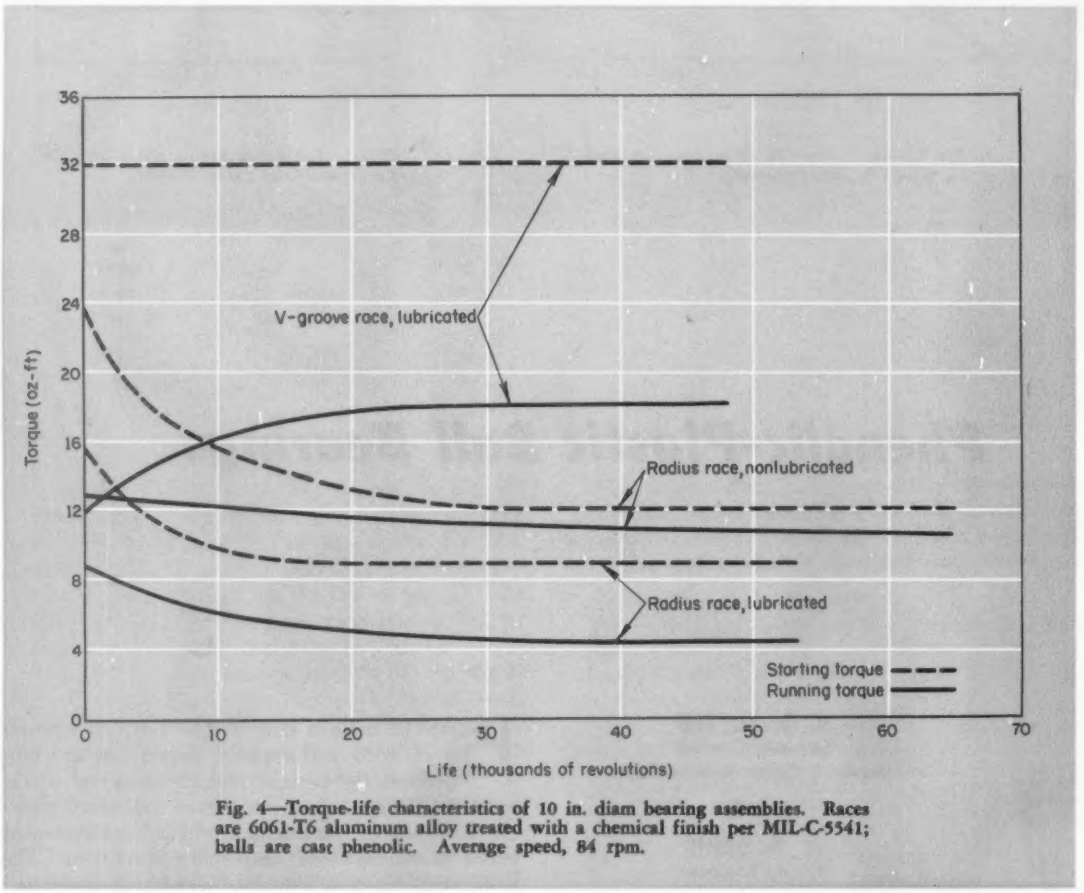

Fig. 4—Torque-life characteristics of 10 in. diam bearing assemblies. Races are 6061-T6 aluminum alloy treated with a chemical finish per MIL-C-5541; balls are cast phenolic. Average speed, 84 rpm.

based on two bearing-race configurations: Full-contact radius, Fig. 3*a*, and V-groove, Fig. 3*b*. Phenolic load-bearing balls 0.4063 ± 0.0005 in. diam were alternated with 0.3937 ± 0.002 in. diam spacer balls. A thrust load of 160 lb was imposed on the inner (rotating) bearing race for all rotation and shock tests. Fig. 4 relates starting and running torques of the two assemblies when run with and without lubrication. Lubricant used was of the solid-film type —molybdenum disulfide in a phenolic-resin base.

Disassembly and examination after test of two full-contact type systems showed no evidence of wear or disintegration of the phenolic balls. They remained within tolerance for diameter and sphericity. Interestingly, markings on the load-carrying balls indicated random rotational movement. However, examination of the V-groove race assembly showed appreciable deterioration. The lubrication was completely removed from the contact areas and the load-carrying balls had pronounced circumferential wear-grooves 0.0015 to 0.0020 in deep.

Shock Testing: A shock test on the bearings, simulating a gun-firing effect, produced no damage of phenolic balls in over 100,000 cycles. Because the shock impacts were made on a rotationally-locked bearing (full-contact type), a slight brinelling of both inner and outer bearing races resulted.

Four-Gear Combinations

. . . a quick method for finding numbers of gear teeth that will approximate a required ratio

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Tool Steel Gear and Pinion Co.
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DESIGNED expressly for machine calculations, the method and the tables presented in this article lead quickly to numbers of teeth on four gears that have a ratio within ±0.000 005 of a specified decimal.

Electric calculating machines with eight or more places and capable of "negative multiplication" are preferable. With this type of calculator and the tables as tools, a four-gear combination usually can be found in less than 3 minutes.

Products of two numbers from 2 to 100 are listed in Table 1. Two sequences of negative multipliers are provided in Table 2. How these tables are used is outlined by the following steps and demonstrated at the same time by a typical numerical example.

Procedure

STEP 1: Set the decimal ratio in the calculator keyboard and lock it. If the desired ratio is greater than unity, use its reciprocal for the calculations and simply invert the finally determined gear pairs.

Example: Suppose the decimal corresponding to

$$\tan 20 \text{ deg} = 0.3639\,7023 \pm 0.000\,005$$

is wanted from a four-gear combination. First, set and lock the decimal 0.3639 7023 in the keyboard of the calculator.

STEP 2: Multiply the decimal ratio by 8100.

$$0.3639\,7023 \times 8100 = 2948.15886300$$

STEP 3: Use the 8100 sequence in Table 2 and multiply negatively in succession by the numbers in the left-hand column, advancing from left to right by columns.

Numbers as follows register on the calculator:

Negative Multiplier	Product Dial	Other Dial
At start	2948.15886300	8100
1	2947.79489277	8099
3	2946.70298208	8096
5	2944.88313093	8091
7	2942.33533932	8084
9	2939.05960725	8075
11	2935.05593472	8064
13	2930.32432173	8051
15	2924.86476828	8036
17	2918.67727437	8019
9	2915.40154230	8010
2	2914.67360184	8008
4	2913.21772092	8004
4	2911.76184000	8000
2	2911.03389954	7998

STEP 4: Observe the product dial on the calculator to spot a number with a decimal portion within ±0.035; that is, smaller than 0.035 or greater than 0.965.

In the example, 2911.0338 9954 has a decimal portion less than 0.035; hence it falls within the prescribed limits.

STEP 5: When a number within the decimal limits is spotted, look in Table 1 to see if the integer ahead of the decimal point is listed. If the integer is listed, a four-gear combination is available. If that integer is not listed in Table 1, then continue the sequence of negative multiplications.

The integer for the example is 2911. This number is listed in Table 1. It is the product of whole numbers

Table 1—Products of Numbers of Teeth

100	2x50	230	5x46	370	5x74	529	23x23	702	18x39	876	12x73	1068	12x89	1271	31x41	1476	18x82
102	2x51	231	3x77	371	7x53	530	10x53	703	19x37	880	10x88	1071	17x63	1272	24x53	1479	29x51
104	2x52	232	4x58	372	4x93	531	9x59	704	8x88	882	18x49	1072	16x67	1273	19x67	1480	37x40
105	5x21	234	3x78	374	11x34	532	14x38	705	15x47	884	26x34	1073	29x37	1274	26x49	1482	38x39
106	2x53	235	5x47	375	5x75	533	13x41	708	12x59	885	15x59	1075	25x43	1275	25x51	1484	28x53
108	2x54	236	4x59	376	4x94	534	6x89	710	10x71	888	24x37	1078	22x49	1276	29x44	1485	27x55
110	2x55	237	3x79	377	13x29	536	8x67	711	9x79	890	10x89	1079	13x83	1278	18x71	1488	31x48
111	3x37	238	7x34	378	6x63	539	11x49	712	8x89	891	11x81	1080	27x40	1280	32x40	1491	21x71
112	2x56	240	4x60	380	5x76	540	10x54	713	23x31	893	19x47	1081	23x47	1281	21x61	1494	18x83
114	2x57	242	11x22	384	4x96	544	8x68	714	14x51	896	16x56	1083	19x57	1287	33x39	1495	23x65
115	5x23	243	3x81	385	5x77	546	6x91	715	13x55	897	23x39	1085	31x35	1288	28x46	1496	34x44
116	2x58	244	4x61	387	9x43	549	9x61	720	10x72	899	29x31	1088	17x64	1290	30x43	1500	30x50
117	3x39	245	5x49	388	4x97	550	10x55	722	19x38	900	10x90	1089	33x33	1292	34x38	1501	19x79
118	2x59	246	3x82	390	5x78	551	19x29	725	25x29	901	17x53	1092	28x39	1295	35x37	1504	32x47
119	7x17	247	13x19	391	17x23	552	8x69	726	22x33	902	22x41	1095	15x73	1296	16x81	1505	35x43
120	2x60	248	4x62	392	4x98	553	7x79	728	8x91	903	21x43	1098	18x61	1298	22x59	1508	29x52
121	11x11	249	3x83	395	5x79	555	15x37	729	27x27	910	10x91	1100	25x44	1300	20x65	1512	27x56
122	2x61	250	5x50	396	4x99	558	6x93	730	10x73	912	16x57	1102	29x38	1302	31x42	1513	17x89
123	3x41	252	4x63	399	7x57	559	13x43	731	17x43	913	11x83	1104	23x48	1305	45x29	1517	37x41
124	2x62	253	11x23	400	5x80	560	10x56	732	12x61	915	15x61	1105	17x65	1309	17x77	1518	33x46
125	5x25	255	5x51	402	6x67	561	17x33	735	15x49	918	27x34	1106	14x79	1311	23x57	1519	31x49
126	2x63	256	4x64	403	13x31	564	6x94	736	8x92	920	10x92	1107	27x41	1312	32x41	1520	38x40
128	2x64	258	3x86	405	5x81	567	7x81	737	11x67	923	13x71	1110	30x37	1314	18x73	1521	39x39
129	3x43	259	7x37	406	7x58	568	8x71	738	18x41	924	12x77	1113	21x53	1316	28x47	1525	25x61
130	5x26	260	5x52	407	11x37	570	10x57	740	10x74	925	25x37	1116	31x36	1320	24x55	1530	18x85
132	2x66	261	3x87	408	8x51	572	22x26	741	19x39	928	16x58	1118	26x43	1323	27x49	1533	21x73
133	7x19	264	4x66	410	5x82	574	14x41	742	14x53	930	10x93	1120	28x40	1325	25x53	1534	26x59
134	2x67	265	5x53	413	7x59	575	23x25	744	8x93	931	19x49	1121	19x59	1326	34x39	1536	24x64
135	5x27	266	7x38	414	6x69	576	8x72	747	9x83	935	17x55	1122	33x34	1328	16x83	1537	29x53
136	2x68	267	3x89	415	5x83	578	17x34	748	22x34	936	12x78	1125	15x75	1330	35x38	1539	27x57
138	2x69	268	4x67	416	8x52	580	10x58	750	10x75	938	14x67	1127	23x49	1332	36x37	1540	35x44
140	2x70	270	5x54	418	11x38	581	7x83	752	8x94	940	10x94	1128	24x47	1333	31x43	1541	23x67
141	3x47	272	4x68	420	5x84	582	6x97	754	13x58	943	23x41	1131	29x39	1334	29x46	1547	17x91
142	2x71	273	3x91	423	9x47	583	11x53	756	12x63	944	16x59	1131	14x81	1335	15x89	1548	18x86
143	11x13	275	5x55	424	8x53	584	8x73	759	23x33	945	21x45	1136	16x71	1340	20x67	1550	25x62
144	2x72	276	4x69	425	5x85	585	13x45	760	10x76	946	22x43	1139	17x67	1342	22x61	1551	33x47
145	5x29	279	3x93	426	6x71	588	6x98	765	17x45	948	12x79	1140	12x95	1343	17x79	1552	16x97
146	2x73	280	5x56	427	7x61	589	19x31	767	13x59	949	13x73	1144	13x88	1344	21x64	1554	37x42
147	3x49	282	3x94	429	11x39	590	10x59	768	8x96	950	10x95	1147	31x37	1349	19x71	1558	38x41
148	2x74	284	4x71	430	5x86	592	8x74	770	10x77	952	28x34	1148	28x41	1350	25x54	1560	24x65
150	2x75	285	5x57	432	8x54	594	6x99	774	18x43	954	18x53	1150	23x50	1352	26x52	1562	22x71
152	2x76	286	11x26	434	14x31	595	17x35	775	25x31	957	29x33	1152	18x64	1353	33x41	1564	34x46
153	3x51	287	7x41	435	5x87	598	23x26	776	8x97	960	10x96	1155	15x77	1357	23x59	1566	27x58
154	2x77	288	4x72	437	19x23	600	10x60	777	21x37	961	31x31	1156	34x34	1358	14x97	1568	32x49
155	5x31	289	17x17	438	6x73	602	14x43	779	19x41	962	26x37	1157	13x89	1360	17x80	1575	25x63
156	2x78	290	5x58	440	5x88	603	9x67	780	10x78	966	14x69	1159	19x61	1363	29x47	1577	19x83
158	2x79	291	3x97	441	9x49	605	11x55	781	11x71	968	22x44	1160	29x40	1364	31x44	1580	20x79
159	3x53	292	4x73	442	17x26	608	8x76	782	23x34	969	19x51	1161	27x43	1365	35x39	1581	31x51
160	2x80	294	3x98	444	12x37	609	21x29	783	27x29	970	10x97	1162	14x83	1368	19x72	1584	36x44
161	7x23	295	5x59	445	5x89	610	10x61	784	8x98	972	12x81	1164	12x97	1369	37x37	1586	26x61
162	2x81	296	4x74	448	8x56	611	13x47	790	10x79	975	25x39	1166	22x53	1372	28x49	1587	23x69
164	2x82	297	3x99	450	5x90	612	12x51	792	8x99	976	16x61	1168	16x73	1375	25x55	1590	30x53
165	5x33	299	13x23	451	11x41	615	15x41	793	13x61	979	11x89	1170	18x65	1376	32x43	1591	37x43
166	2x83	300	3x100	455	5x91	616	8x77	795	15x53	980	10x98	1173	23x51	1377	17x81	1593	27x59
168	2x84	301	7x43	456	8x57	620	10x62	798	14x57	984	12x82	1175	25x47	1378	26x53	1595	29x55
169	13x13	304	4x76	459	17x27	621	23x27	799	17x47	986	29x34	1176	24x49	1380	23x60	1596	28x57
170	2x85	305	5x61	460	5x92	623	7x89	800	10x80	987	21x47	1178	31x38	1386	18x77	1598	34x47
171	3x57	306	6x51	462	6x77	624	8x78	801	9x89	988	26x38	1180	20x59	1387	19x73	1599	39x41
172	2x86	308	4x77	464	8x58	625	25x25	803	11x73	989	23x43	1183	13x91	1392	29x48	1600	40x40
174	2x87	310	5x62	465	5x93	627	19x33	804	12x67	990	10x99	1184	32x37	1394	34x41	1602	18x89
175	5x35	312	4x78	468	6x78	629	17x37	805	23x35	992	16x62	1185	15x79	1395	31x45	1606	22x73
176	2x88	315	5x63	469	7x67	630	10x63	806	26x31	994	14x71	1188	27x44	1400	25x56	1608	24x67
177	3x59	316	4x79	470	5x94	632	8x79	810	10x81	996	12x83	1189	29x41	1403	23x61	1610	23x70
178	2x89	318	6x53	472	8x59	636	12x53	812	14x58	999	27x37	1190	17x70	1404	27x52	1612	26x62
180	2x90	319	11x29	473	11x43	637	13x49	814	22x37	1000	20x50	1196	26x46	1406	37x38	1615	19x85
182	2x91	320	5x64	474	6x79	638	11x58	816	16x51	1001	13x77	1197	19x63	1407	21x67	1617	33x49
183	3x61	322	7x46	475	5x95	639	13x49	817	19x43	1003	17x59	1200	24x50	1408	22x64	1620	20x81
184	2x92	323	17x19	476	14x34	640	10x64	819	9x91	1005	15x67	1204	28x43	1410	30x47	1624	29x56
185	5x37	324	4x81	477	9x53	644	14x46	820	10x82	1007	19x53	1206	18x67	1411	17x83	1625	25x65
186	2x93	325	5x65	480	5x96	645	15x43	825	25x33	1008	16x63	1207	17x71	1416	24x59	1628	37x44
187	11x17	328	4x82	481	13x37	646	17x38	826	14x59	1012	23x44	1209	31x39	1419	33x43	1632	32x51
188	2x94	329	7x47	483	7x69	648	8x81	828	12x69	1014	26x39	1210	22x55	1420	20x71	1633	23x71
189	3x63	330	5x66	484	22x22	649	11x59	830	10x83	1015	29x35	1215	15x81	1421	29x49	1634	38x43
190	2x95	332	4x83	485	5x97	650	10x65	832	16x52	1020	20x51	1216	19x64	1422	18x79	1638	26x63
192	2x96	333	9x37	486	6x81	651	21x31	833	17x49	1022	14x73	1218	29x42	1424	16x89	1640	40x41
194	2x97	335	5x67	488	8x61	656	8x82	836	22x38	1023	31x33	1219	23x53	1425	19x75	1643	31x53
195	5x39	336	4x84	490	5x98	657	9x73	837	27x31	1024	16x64	1220	20x61	1426	31x46	1645	35x47
196	2x98	338	13x26	492	6x82	658	14x47	840	10x84	1025	25x41	1221	33x37	1428	21x68	1647	27x61
198	2x99	340	5x68	493	17x29	660	10x66	841	29x29	1026	27x38	1222	26x47	1430	26x55	1649	11x97
200	2x100	341	11x31	494	19x26	663	17x39	845	13x65	1027	13x79	1224	17x72	1431	27x53	1650	30x55
201	3x67	342	6x57	495	5x99	664	8x83	846	18x47	1029	21x49	1225	25x49	1435	35x41	1652	28x59
203	7x29	343	7x49	496	8x62	665	19x35	847	11x77	1032	12x86	1230	30x41	1440	32x45	1653	29x57
204	4x51	344	4x86	497	7x71	666	18x37	848	16x53	1034	22x47	1232	28x44	1443	37x39	1656	24x69
205	5x41	345	5x69	498	6x83	667	23x29	850	10x85	1035	23x45	1235	19x65	1444	38x38	1659	21x79
207	3x69	348	4x87	500	5x100	670	10x67	851	23x37	1036	28x37	1239	21x59	1445	17x85	1660	20x83
208	4x52	350	5x70	504	8x63	671	11x61	852	12x71	1037	17x61	1240	31x40	1449	23x63	1664	26x64
209	11x19	351	9x39	506	22x23	672	8x84	854	14x61	1040	20x52	1241	17x73	1450	29x50	1665	37x45
210	5x42	352	4x88	507	13x39	675	25x27	855	19x45	1044	12x87	1242	23x54	1452	33x44	1666	34x49
212	4x53	354	6x59	510	10x51	676	26x26	858	22x39	1045	19x55	1245	15x83	1455	15x97	1672	38x44
213	3x71	355	5x71	511	7x73	680	10x68	860	10x86	1050	21x50	1246	14x89	1456	28x52	1674	27x62
215	5x43	356	4x89	512	8x64	682	22x31	861	21x41	1053	13x81	1247	29x43	1457	31x47	1675	25x67
216	4x54	357	7x51	513	19x27	684	12x57	864	16x54	1054	31x34	1248	13x96	1458	27x54	1677	39x43
217	7x31	360	5x72	516	6x86	686	14x49	867	17x51	1056	16x66	1250	25x50	1460	20x73	1679	23x73
219	3x73	361	19x19	517	11x47	688	8x86	868	28x31	1058	23x46	1254	33x38	1462	34x43	1680	35x48
220	5x44	363	11x33	518	14x37	689	13x53	869	11x79	1060	20x53	1258	34x37	1463	19x77	1681	41x41
221	13x17	364	4x91	520	10x52	690	10x69	870	10x87	1062	18x59	1260	35x36	1464	24x61	1682	29x58
222	3x74	365	5x73	522	6x87	693	9x77	871	13x67	1064	19x56	1261	13x97	1470	30x49	1683	33x51
224	4x56	366	6x61	525	21x25	696	8x87	873	9x97	1065	15x71	1264	16x79	1472	23x64	1690	26x65
225	5x45	368	4x92	527	17x31	697	17x41	874	23x38	1066	26x41	1265	23x55	1474	22x67	1691	19x89
228	4x57	369	9x41	528	8x66	700	10x70	875	25x35	1067	11x97	1269	27x47	1475	25x59	1692	36x47

1694 22x77	1920 30x64	2150 43x50	2401 49x49	2652 39x68	2914 47x62	3192 56x57	3476 44x79	3762 38x99
1696 32x53	1922 31x62	2156 44x49	2403 27x89	2655 45x59	2915 53x55	3195 45x71	3477 57x61	3763 53x71
1700 34x50	1924 37x52	2158 26x83	2405 37x65	2656 32x83	2916 54x54	3196 47x68	3478 47x74	3770 58x65
1701 27x63	1925 25x77	2160 45x48	2407 29x83	2660 35x76	2920 40x73	3198 39x82	3479 49x71	3772 46x82
1702 37x46	1927 41x47	2162 46x47	2408 43x56	2664 36x74	2923 37x79	3200 40x80	3480 40x87	3773 49x77
1704 24x71	1932 28x69	2166 38x57	2409 33x73	2665 41x65	2924 34x86	3201 33x97	3481 59x59	3774 51x74
1705 31x55	1935 43x45	2170 35x62	2412 36x67	2666 43x62	2925 39x75	3204 36x89	3483 43x81	3776 59x64
1708 28x61	1936 44x44	2173 41x53	2414 34x71	2668 46x58	2926 38x77	3212 44x73	3484 52x67	3780 54x70
1710 38x45	1938 38x51	2175 29x75	2415 35x69	2670 30x89	2928 48x61	3213 51x63	3485 41x85	3782 61x62
1711 29x59	1940 20x97	2176 32x68	2418 39x62	2673 33x81	2937 33x89	3216 48x67	3486 42x83	3783 39x97
1715 35x49	1943 29x67	2178 33x66	2419 41x59	2679 47x57	2940 49x60	3219 37x87	3492 36x97	3784 43x88
1716 39x44	1944 24x81	2183 37x59	2420 44x55	2680 40x67	2944 46x64	3220 46x70	3496 46x76	3792 48x79
1720 40x43	1947 33x59	2184 24x91	2425 25x97	2684 44x61	2945 31x95	3224 52x62	3498 53x66	3795 55x69
1722 41x42	1950 25x78	2185 23x95	2430 30x81	2686 34x79	2948 44x67	3225 43x75	3500 50x70	3796 52x73
1725 23x75	1952 32x61	2187 27x81	2432 38x64	2688 48x56	2950 50x59	3230 38x85	3504 48x73	3800 50x76
1728 27x64	1953 31x63	2190 30x73	2436 42x58	2691 39x69	2952 36x82	3233 53x61	3510 54x65	3807 47x81
1729 19x91	1955 23x85	2193 43x51	2438 46x53	2695 49x55	2958 51x58	3234 49x66	3515 37x95	3808 56x68
1734 34x51	1958 22x89	2196 36x61	2440 40x61	2697 31x87	2960 40x74	3237 39x83	3519 51x69	3813 41x93
1736 31x56	1960 40x49	2200 40x55	2442 37x66	2698 38x71	2961 47x63	3239 41x79	3520 55x64	3816 53x72
1738 22x79	1961 33x53	2201 31x71	2444 47x52	2700 50x54	2964 39x76	3240 40x81	3525 47x75	3818 46x83
1739 37x47	1968 41x48	2204 38x58	2448 48x51	2701 37x73	2967 43x69	3243 47x69	3526 43x82	3819 57x67
1740 29x60	1971 27x73	2205 45x49	2449 31x79	2703 51x53	2968 53x56	3245 55x59	3528 49x72	3822 49x78
1742 26x67	1972 34x58	2208 32x69	2450 49x50	2704 52x52	2970 55x54	3248 56x58	3534 57x62	3825 51x75
1743 21x83	1974 42x47	2209 47x47	2451 43x57	2706 41x66	2976 48x62	3249 57x57	3536 52x68	3827 43x89
1746 18x97	1975 25x79	2210 34x65	2457 39x63	2709 43x63	2982 42x71	3250 50x65	3538 58x61	3828 58x66
1748 38x46	1976 38x52	2211 33x67	2460 41x60	2714 46x59	2988 36x83	3255 35x93	3540 59x60	3834 54x71
1749 33x53	1978 43x46	2212 28x79	2464 32x77	2716 28x97	2989 49x61	3256 37x88	3542 46x77	3835 59x65
1750 35x50	1980 36x55	2214 41x54	2465 29x85	2720 40x68	2990 46x65	3264 51x64	3549 39x91	3840 60x64
1752 24x73	1984 31x64	2220 37x60	2470 38x65	2726 47x58	2992 44x68	3266 46x71	3550 50x71	3843 61x63
1755 27x65	1988 28x71	2223 39x57	2475 45x55	2728 31x88	2993 41x73	3267 33x99	3551 53x67	3844 62x62
1760 32x55	1989 39x51	2225 25x89	2478 42x59	2730 30x91	2997 37x81	3268 38x86	3552 48x74	3848 52x74
1763 41x43	1992 24x83	2226 42x53	2479 37x67	2736 48x57	3000 50x60	3276 36x91	3555 45x79	3850 50x77
1764 36x49	1995 35x57	2231 23x97	2480 31x80	2738 37x74	3002 38x79	3280 40x82	3560 40x89	3854 47x82
1767 31x57	1998 37x54	2232 36x62	2482 34x73	2739 33x83	3003 39x77	3283 49x67	3564 36x99	3861 39x99
1768 34x52	2000 40x50	2233 29x77	2484 36x69	2744 49x56	3007 31x97	3285 45x73	3567 41x87	3864 56x69
1769 29x61	2001 29x69	2236 43x52	2485 35x71	2745 45x61	3008 47x64	3286 53x62	3569 43x83	3869 53x73
1770 30x59	2002 26x77	2240 35x64	2490 30x83	2747 41x67	3009 51x59	3290 47x70	3570 42x85	3870 45x86
1771 23x77	2006 34x59	2241 27x83	2491 47x53	2750 50x55	3010 43x70	3293 37x89	3572 47x76	3871 49x79
1775 25x71	2009 41x49	2242 38x59	2492 28x89	2752 43x64	3015 45x67	3294 54x61	3575 55x65	3872 44x88
1776 37x48	2010 30x67	2244 44x51	2494 43x58	2754 51x54	3016 52x58	3298 34x97	3577 49x73	3876 57x68
1780 20x89	2013 33x61	2250 45x50	2496 39x64	2755 29x95	3021 53x57	3300 50x66	3584 56x64	3880 40x97
1782 22x81	2014 38x53	2254 46x49	2499 49x51	2756 52x53	3024 36x84	3304 56x59	3588 39x92	3886 58x67
1785 35x51	2015 31x65	2255 41x55	2500 50x50	2759 31x89	3025 55x55	3306 57x58	3589 37x97	3888 48x81
1786 38x47	2016 32x63	2256 47x48	2501 41x61	2760 40x69	3026 34x89	3311 43x77	3591 57x63	3894 59x66
1792 28x64	2021 43x47	2257 37x61	2508 44x57	2765 35x79	3034 41x74	3312 46x72	3596 58x62	3895 41x95
1794 39x46	2024 44x46	2262 39x58	2511 31x81	2769 39x71	3036 44x69	3315 51x65	3599 59x61	3900 50x78
1798 31x58	2025 45x45	2263 31x73	2516 37x68	2772 36x77	3038 49x62	3318 42x79	3600 60x60	3901 47x83
1800 25x72	2028 39x52	2268 28x81	2520 45x56	2773 47x59	3040 32x95	3320 40x83	3604 53x68	3904 61x64
1802 34x53	2030 35x58	2272 32x71	2522 26x97	2774 38x73	3042 39x78	3321 41x81	3608 41x88	3905 55x71
1804 41x44	2035 37x55	2275 35x65	2523 29x87	2775 37x75	3045 35x87	3325 35x95	3610 38x95	3906 42x93
1805 19x95	2037 21x97	2277 33x69	2528 32x79	2784 29x96	3050 50x61	3328 52x64	3612 42x86	3910 46x85
1806 42x43	2040 40x51	2278 34x67	2530 46x55	2788 34x82	3053 43x71	3330 45x74	3618 54x67	3913 43x91
1809 27x67	2044 28x73	2279 43x53	2535 39x65	2790 45x62	3055 47x65	3332 49x68	3619 47x77	3915 45x87
1813 37x49	2046 33x62	2280 40x57	2537 43x59	2793 49x57	3060 36x85	3337 47x71	3621 51x71	3916 44x89
1815 33x55	2047 23x89	2288 44x52	2538 47x54	2795 43x65	3066 42x73	3339 53x63	3626 49x74	3920 49x80
1817 23x79	2048 32x64	2291 29x79	2541 33x77	2800 50x56	3068 52x59	3344 44x76	3627 39x93	3922 53x74
1820 35x52	2050 41x50	2294 37x62	2542 41x62	2805 51x55	3069 31x99	3348 36x93	3630 55x66	3927 51x77
1824 32x57	2052 38x54	2295 27x85	2544 48x53	2806 46x61	3071 37x83	3350 50x67	3634 46x79	3933 57x69
1825 25x73	2054 26x79	2296 41x56	2546 38x67	2808 39x72	3072 48x64	3354 39x86	3640 56x65	3936 48x82
1826 22x83	2058 42x49	2300 46x50	2548 28x91	2809 53x53	3074 53x58	3355 55x61	3645 45x81	3942 54x73
1827 29x63	2059 29x71	2301 39x59	2550 34x75	2812 38x74	3075 41x75	3358 46x73	3648 57x64	3944 58x68
1829 31x59	2064 43x48	2303 47x49	2552 29x88	2813 29x97	3078 38x81	3360 48x70	3649 41x89	3948 47x84
1830 30x61	2065 35x59	2304 36x64	2553 37x69	2814 42x67	3080 40x77	3362 41x82	3650 50x73	3950 50x79
1833 39x47	2067 39x53	2310 35x66	2555 35x73	2816 44x64	3081 39x79	3363 57x59	3652 44x83	3952 52x76
1836 27x68	2068 44x47	2312 34x68	2556 36x71	2820 47x60	3082 46x67	3364 58x58	3654 58x63	3953 59x67
1840 20x92	2070 45x46	2314 26x89	2560 40x64	2821 31x91	3087 49x63	3366 51x66	3655 43x85	3956 46x86
1843 19x97	2072 37x56	2318 38x61	2562 42x61	2822 34x83	3094 34x91	3367 37x91	3657 53x69	3960 55x72
1845 41x45	2074 31x61	2320 40x58	2565 45x57	2829 41x69	3096 43x72	3375 45x75	3658 59x62	3965 61x65
1846 26x71	2075 25x83	2322 43x54	2573 31x83	2832 48x59	3100 50x62	3380 52x65	3660 60x61	3968 62x64
1848 24x77	2077 31x67	2324 28x83	2574 39x66	2835 35x81	3102 47x66	3381 49x63	3663 37x99	3969 63x63
1849 43x43	2079 33x63	2325 25x93	2576 46x56	2838 43x66	3104 32x97	3382 38x89	3666 47x78	3975 53x75
1850 37x50	2080 32x65	2328 24x97	2580 43x60	2840 40x71	3105 45x69	3384 36x94	3672 51x72	3976 56x71
1855 35x53	2088 36x58	2331 37x63	2581 29x89	2842 49x58	3108 42x74	3388 44x77	3675 49x75	3977 41x97
1856 29x64	2090 38x55	2332 44x53	2583 41x63	2844 36x79	3111 51x61	3392 53x64	3680 46x80	3978 51x78
1860 31x60	2091 41x51	2336 32x73	2584 38x68	2847 39x73	3115 35x89	3393 39x87	3685 55x67	3984 48x83
1862 38x49	2093 23x91	2337 41x57	2585 47x55	2848 32x89	3116 41x76	3395 35x97	3686 38x97	3990 57x70
1863 23x81	2100 30x70	2340 36x65	2590 37x70	2849 37x77	3120 48x65	3397 43x79	3690 45x82	3995 47x85
1869 21x89	2106 26x81	2343 33x71	2592 32x81	2850 38x75	3124 44x71	3400 50x68	3692 52x71	3996 54x74
1870 34x55	2107 43x49	2345 35x67	2596 44x59	2852 46x62	3127 53x59	3402 42x81	3696 48x77	3999 43x93
1872 36x52	2108 34x62	2346 34x69	2597 49x53	2856 51x56	3128 46x68	3403 41x83	3698 43x86	4000 50x80
1875 25x75	2109 37x57	2349 29x81	2600 52x50	2860 52x55	3132 36x87	3404 46x74	3700 50x74	4002 58x69
1876 28x67	2112 33x64	2350 47x50	2601 51x51	2862 53x54	3135 55x57	3408 48x71	3705 57x65	4004 52x77
1880 40x47	2115 45x47	2352 48x49	2604 28x93	2867 47x61	3136 49x64	3410 55x62	3710 53x70	4005 45x89
1881 33x57	2116 46x46	2356 38x62	2607 33x79	2870 41x70	3139 43x73	3416 56x61	3712 58x64	4012 59x68
1885 29x65	2117 29x73	2360 40x59	2610 45x58	2871 29x99	3145 37x85	3417 51x67	3713 47x79	4015 55x73
1886 41x46	2120 40x53	2365 43x55	2613 39x67	2880 45x64	3149 47x67	3420 45x76	3717 59x63	4018 49x82
1887 37x51	2124 36x59	2366 26x91	2618 34x77	2881 43x67	3150 50x63	3422 58x59	3720 40x93	4020 60x67
1888 32x59	2125 25x85	2368 37x64	2619 27x97	2883 31x93	3154 38x83	3430 49x70	3721 61x61	4026 61x66
1890 35x54	2128 28x76	2370 30x79	2622 46x57	2886 39x74	3157 41x77	3431 47x73	3723 51x73	4028 53x76
1891 31x61	2130 30x71	2375 25x95	2623 43x61	2888 38x76	3159 39x81	3432 44x78	3724 49x76	4029 51x79
1892 43x44	2132 41x52	2376 27x88	2624 41x64	2890 34x85	3160 40x79	3440 40x86	3726 46x81	4030 62x65
1896 24x79	2133 27x79	2378 41x58	2625 35x75	2891 49x59	3162 51x62	3441 37x93	3731 41x91	4032 63x64
1898 26x73	2134 22x97	2379 39x61	2627 37x71	2898 46x63	3168 44x72	3444 42x82	3735 45x83	4042 47x86
1900 38x50	2135 35x61	2380 28x85	2628 36x73	2900 50x58	3172 52x61	3445 53x65	3738 42x89	4047 57x71
1904 34x56	2136 24x89	2385 45x53	2632 47x56	2904 33x88	3174 46x69	3450 50x69	3740 55x68	4048 46x88
1908 36x53	2139 31x69	2387 31x77	2635 31x85	2905 35x83	3180 53x60	3456 54x64	3741 43x87	4050 50x81
1909 23x83	2142 34x63	2392 46x52	2639 29x91	2907 51x57	3182 43x74	3458 38x91	3744 52x72	4056 52x78
1911 39x49	2144 32x67	2394 38x63	2640 48x55	2910 30x97	3185 49x65	3465 45x77	3750 50x75	4059 41x99
1914 33x58	2145 39x55	2397 47x51	2646 27x98	2911 41x71	3186 54x59	3471 39x89	3752 56x67	4060 58x70
1917 27x71	2146 37x58	2400 40x60	2650 50x53	2912 32x91	3190 55x58	3472 56x62	3760 47x80	4067 49x83

Table 1 (cont.)

4070 55x74	4386 51x86	4725 63x75	5074 59x86	5445 55x99	5846 74x79	6290 74x85	6816 71x96	7426 79x94
4071 59x69	4389 57x77	4730 55x86	5076 54x94	5451 69x79	5848 68x86	6298 67x94	6825 75x91	7440 80x93
4074 42x97	4392 61x72	4731 57x83	5082 66x77	5452 58x94	5850 65x90	6300 63x100	6831 69x99	7448 76x98
4080 48x85	4399 53x83	4732 52x91	5084 62x82	5456 62x88	5852 76x77	6308 76x83	6840 72x95	7452 81x92
4081 53x77	4400 50x88	4736 64x74	5088 53x96	5460 60x91	5856 61x96	6314 77x82	6853 77x89	7462 82x91
4085 43x95	4402 62x71	4740 60x79	5092 67x76	5467 71x77	5859 63x93	6318 78x81	6860 70x98	7469 77x97
4087 61x67	4408 58x76	4743 51x93	5096 56x91	5472 57x96	5865 69x85	6319 71x89	6862 73x94	7470 83x90
4088 56x73	4410 63x70	4745 65x73	5100 51x100	5476 74x74	5874 60x89	6320 79x80	6864 78x88	7476 84x89
4089 47x87	4416 64x69	4750 50x95	5103 63x81	5478 66x83	5880 60x98	6324 68x93	6873 79x87	7480 85x88
4092 44x93	4418 47x94	4752 48x99	5104 58x88	5481 63x87	5888 64x92	6336 72x88	6880 80x86	7482 86x87
4094 46x89	4420 65x68	4753 49x97	5106 69x74	5487 59x93	5890 62x95	6351 73x87	6882 74x93	7488 78x96
4095 45x91	4422 66x67	4756 58x82	5110 70x73	5488 56x98	5893 71x83	6364 74x86	6885 81x85	7500 75x100
4096 64x64	4424 56x79	4757 67x71	5112 71x72	5490 61x90	5896 67x88	6365 67x95	6887 71x97	7505 79x95
4100 50x82	4425 59x75	4758 61x78	5115 55x93	5494 67x82	5900 59x100	6370 65x98	6888 82x84	7520 80x94
4104 57x72	4428 54x82	4760 56x85	5120 64x80	5500 55x100	5904 72x82	6375 75x85	6889 83x83	7524 76x99
4108 52x79	4437 51x87	4761 69x69	5124 61x84	5504 64x86	5913 73x81	6384 76x84	6900 69x100	7533 81x93
4116 49x84	4440 60x74	4770 53x90	5130 54x95	5508 68x81	5915 65x91	6390 71x90	6912 72x96	7544 82x92
4118 58x71	4446 57x78	4774 62x77	5133 59x87	5510 58x95	5916 68x87	6391 77x83	6916 76x91	7546 77x98
4125 55x75	4450 50x89	4779 59x81	5135 65x79	5518 62x82	5917 61x97	6392 68x94	6930 77x90	7553 83x91
4128 48x86	4452 53x84	4784 52x92	5141 53x97	5520 60x92	5920 74x80	6396 78x82	6935 73x95	7560 84x90
4130 59x70	4453 61x73	4785 55x87	5146 62x83	5525 65x85	5922 63x94	6399 79x81	6942 78x89	7565 85x89
4131 51x81	4455 55x81	4788 63x76	5148 52x99	5529 57x97	5925 75x79	6400 64x100	6952 79x88	7566 78x97
4134 53x78	4459 49x91	4794 51x94	5152 56x92	5530 70x79	5928 76x78	6402 66x97	6956 74x94	7568 86x88
4136 47x88	4462 46x97	4800 50x96	5159 67x77	5538 71x78	5929 77x77	6408 72x89	6958 71x98	7569 87x87
4140 60x69	4464 48x93	4802 49x98	5160 60x86	5544 72x77	5934 69x86	6417 69x93	6960 80x87	7584 79x96
4144 56x74	4465 47x95	4806 54x89	5162 58x89	5546 59x94	5940 60x99	6424 73x88	6966 81x86	7600 76x100
4148 61x68	4466 58x77	4810 65x74	5166 63x82	5548 73x76	5950 70x85	6432 67x96	6970 82x83	7614 81x94
4150 50x83	4472 52x86	4814 58x83	5168 68x76	5550 74x75	5952 64x93	6435 65x99	6972 83x84	7623 77x99
4154 62x67	4473 63x71	4816 56x86	5170 55x94	5551 61x91	5963 67x89	6438 74x87	6975 75x93	7626 82x93
4158 54x77	4480 64x70	4818 66x73	5175 69x75	5561 67x83	5964 71x84	6440 70x92	6984 72x79	7636 83x92
4160 64x65	4482 54x83	4819 61x79	5180 70x74	5568 64x87	5976 72x83	6450 75x86	6992 76x92	7644 84x91
4161 57x73	4484 59x76	4823 53x91	5183 71x73	5576 68x82	5978 61x98	6460 76x85	7000 70x100	7650 85x90
4165 49x85	4485 65x69	4824 67x72	5184 64x81	5580 60x93	5980 65x92	6461 71x91	7007 77x91	7654 86x89
4171 43x97	4488 66x68	4828 68x71	5185 61x85	5586 57x98	5984 68x88	6468 66x98	7008 73x96	7656 87x88
4176 48x87	4489 67x67	4830 69x70	5187 57x91	5589 69x81	5985 63x95	6478 79x82	7020 78x90	7663 79x97
4180 55x76	4500 50x90	4836 52x93	5192 59x88	5590 65x86	5986 73x82	6480 80x81	7029 71x99	7680 80x96
4182 51x82	4503 57x79	4838 59x82	5194 53x98	5600 56x100	5994 74x81	6486 69x94	7030 74x95	7695 81x95
4183 47x89	4505 53x85	4840 55x88	5200 52x100	5605 59x95	6000 60x100	6497 73x89	7031 79x89	7700 77x100
4185 45x93	4508 49x92	4845 57x85	5208 56x93	5607 63x89	6003 69x87	6499 67x97	7040 80x88	7708 82x94
4186 46x91	4510 55x82	4850 50x97	5214 66x79	5609 71x79	6004 76x79	6500 65x100	7047 81x87	7719 83x93
4187 53x79	4512 48x94	4851 49x99	5220 60x87	5610 66x85	6006 77x78	6510 70x93	7050 75x94	7722 78x99
4189 59x71	4514 61x74	4860 60x81	5225 55x95	5612 61x92	6014 62x97	6525 75x87	7052 82x86	7728 84x92
4200 50x84	4524 52x87	4864 64x76	5226 67x78	5616 72x78	6016 64x94	6528 68x96	7055 83x85	7735 85x91
4209 61x69	4526 62x73	4872 56x87	5229 63x83	5621 73x77	6020 70x86	6532 71x92	7056 72x98	7740 86x90
4212 52x81	4536 56x81	4875 65x75	5236 68x77	5624 74x76	6030 67x90	6534 66x99	7068 76x93	7742 79x98
4214 49x86	4539 51x89	4876 53x92	5238 54x97	5625 75x75	6035 71x85	6536 76x86	7081 73x97	7743 87x89
4216 62x68	4543 59x77	4880 61x80	5244 57x92	5626 58x97	6039 61x99	6545 77x85	7084 77x92	7744 88x88
4218 57x74	4544 64x71	4884 66x74	5246 61x86	5628 67x84	6045 65x93	6552 72x91	7098 78x91	7760 80x97
4221 63x67	4550 50x91	4888 52x94	5247 53x99	5632 64x88	6048 72x84	6555 69x95	7100 71x100	7776 81x96
4224 64x66	4554 66x69	4891 67x73	5248 64x82	5640 60x94	6052 68x89	6557 79x83	7104 74x96	7790 82x95
4225 65x65	4556 67x68	4895 55x89	5250 70x75	5642 62x91	6059 73x83	6560 80x82	7110 79x90	7800 78x100
4230 45x94	4557 49x93	4896 51x96	5251 59x89	5643 57x99	6068 74x82	6561 81x81	7120 80x89	7802 83x94
4232 46x92	4558 53x86	4897 59x83	5254 71x74	5644 68x83	6072 69x88	6566 67x98	7125 75x95	7812 84x93
4233 51x83	4559 47x97	4898 62x79	5256 72x73	5655 65x87	6075 75x81	6570 73x90	7128 81x88	7820 85x92
4234 58x73	4560 48x95	4899 69x71	5264 56x94	5658 69x82	6076 62x98	6580 70x94	7134 82x87	7821 79x99
4235 55x77	4565 55x83	4900 70x70	5265 65x81	5664 59x96	6080 64x95	6586 74x89	7138 83x86	7826 86x91
4240 53x80	4575 61x75	4902 57x86	5270 62x85	5670 70x81	6083 77x79	6596 68x97	7140 84x85	7830 87x90
4248 59x72	4576 52x88	4914 54x91	5278 58x91	5673 61x93	6084 78x78	6600 66x100	7144 76x94	7832 88x89
4250 50x85	4582 58x79	4920 60x82	5280 55x96	5676 66x86	6090 70x87	6603 71x93	7154 73x98	7840 80x98
4256 56x76	4588 62x74	4928 64x77	5292 54x98	5680 71x80	6097 67x91	6612 76x87	7161 77x93	7857 81x97
4260 60x71	4590 54x85	4929 53x93	5293 67x79	5684 58x98	6100 61x100	6622 77x86	7176 78x92	7872 82x96
4263 49x87	4592 56x82	4930 58x85	5300 53x100	5688 72x79	6106 71x86	6624 69x96	7178 74x97	7885 83x95
4264 52x82	4599 63x73	4940 52x95	5301 57x93	5694 73x78	6110 65x94	6630 79x85	7189 79x91	7896 84x94
4266 54x79	4600 50x92	4941 61x81	5304 68x78	5695 67x85	6111 63x97	6633 67x99	7200 72x100	7900 79x100
4268 44x97	4602 59x78	4947 51x97	5307 61x87	5696 64x89	6120 72x85	6636 80x84	7209 81x89	7905 85x93
4270 61x70	4606 49x94	4950 55x90	5310 59x90	5698 74x77	6132 73x84	6640 80x83	7216 82x88	7912 86x92
4272 48x89	4608 64x72	4956 59x84	5312 64x83	5700 57x100	6138 62x99	6642 81x82	7220 76x95	7917 87x91
4275 57x75	4611 53x87	4958 67x74	5313 69x77	5704 62x92	6141 69x89	6643 73x91	7221 83x87	7920 88x90
4277 47x91	4615 65x71	4959 57x87	5320 70x76	5712 68x84	6142 74x83	6650 70x95	7224 84x86	7921 89x89
4278 62x69	4617 57x81	4960 62x80	5325 71x75	5720 65x88	6144 64x96	6660 74x90	7225 85x85	7938 81x98
4284 51x84	4620 60x77	4964 68x73	5328 72x74	5723 59x97	6150 75x82	6664 68x98	7227 73x99	7954 82x97
4288 64x67	4623 67x69	4968 69x72	5329 73x73	5727 69x83	6156 76x81	6674 71x94	7238 77x94	7968 83x96
4290 65x66	4624 68x68	4970 70x71	5330 65x82	5733 63x91	6160 70x88	6675 75x89	7252 74x98	7980 84x95
4292 58x74	4628 52x89	4977 63x79	5332 62x86	5734 61x94	6162 78x79	6688 76x88	7254 78x93	7990 85x94
4293 53x81	4636 61x76	4980 60x83	5335 55x97	5740 70x82	6164 67x92	6693 69x97	7268 79x92	7998 86x93
4300 50x86	4640 58x80	4982 53x94	5336 58x92	5742 66x87	6174 63x98	6696 72x93	7275 75x97	8000 80x100
4307 59x73	4641 51x91	4984 56x89	5340 60x89	5751 71x81	6175 65x95	6699 77x87	7280 80x91	8004 87x92
4312 49x88	4644 54x86	4988 58x86	5346 66x81	5760 64x90	6177 71x87	6700 67x100	7290 81x90	8008 88x91
4316 52x83	4648 56x83	4992 64x78	5355 63x85	5762 67x86	6188 65x91	6708 78x86	7296 76x96	8010 89x90
4320 54x80	4650 50x93	4998 51x98	5358 57x94	5766 62x93	6192 72x86	6715 80x85	7298 82x89	8019 81x99
4324 46x94	4653 47x99	5000 50x100	5360 67x80	5767 73x79	6200 62x100	6716 73x92	7300 73x100	8036 82x98
4331 61x71	4655 49x95	5002 61x82	5368 61x88	5772 74x78	6204 66x94	6720 80x84	7304 83x88	8051 83x97
4332 57x76	4656 48x97	5005 65x77	5369 59x91	5775 75x77	6205 73x85	6723 81x83	7308 84x87	8064 84x96
4335 51x85	4661 59x79	5015 59x85	5372 68x79	5776 76x76	6208 64x97	6724 82x82	7310 85x86	8075 85x95
4340 62x70	4662 63x74	5016 57x88	5376 64x84	5780 68x85	6210 69x90	6732 68x99	7315 77x95	8084 86x94
4345 55x79	4664 53x88	5022 62x81	5382 69x78	5782 59x98	6216 74x84	6734 73x91	7326 74x99	8091 87x93
4346 53x82	4672 64x73	5025 67x75	5390 55x98	5785 65x89	6225 75x83	6745 71x95	7332 78x94	8096 88x92
4347 63x69	4674 57x82	5032 68x74	5394 58x93	5795 61x95	6230 70x89	6750 75x90	7347 79x93	8099 89x91
4350 50x87	4675 55x85	5035 53x95	5395 65x83	5796 69x84	6231 67x93	6762 69x98	7350 75x98	8100 81x100
4352 64x68	4680 65x72	5037 69x73	5396 71x76	5800 58x100	6232 76x82	6764 76x89	7360 80x92	8118 82x99
4355 65x67	4686 66x71	5040 72x70	5400 54x100	5808 66x88	6237 77x81	6768 72x94	7371 81x91	8134 83x98
4356 66x66	4690 67x70	5041 71x71	5402 73x74	5810 70x83	6240 65x96	6776 77x88	7372 76x97	8148 84x97
4361 49x89	4692 51x92	5044 52x97	5412 66x82	5820 60x97	6241 79x79	6786 78x87	7380 82x90	8160 85x96
4365 45x97	4697 61x77	5046 58x78	5415 57x95	5822 71x82	6248 71x88	6789 73x93	7387 83x89	8170 86x95
4366 59x74	4698 58x81	5049 51x99	5418 63x86	5824 64x91	6256 68x92	6790 70x97	7392 84x88	8178 87x94
4368 48x91	4700 50x94	5056 64x79	5427 67x81	5828 62x94	6264 72x87	6794 79x86	7395 85x87	8184 88x93
4370 46x95	4704 49x96	5060 55x92	5428 59x92	5829 87x67	6270 66x95	6800 68x100	7396 86x86	8188 89x92
4371 47x93	4712 62x76	5063 61x83	5429 61x89	5832 72x81	6272 64x98	6804 81x84	7400 74x100	8190 90x91
4374 54x81	4717 53x89	5070 65x78	5432 56x97	5840 73x80	6278 73x86	6806 82x83	7410 78x95	8200 82x100
4380 60x73	4720 59x80	5073 57x89	5440 64x85	5841 59x99	6279 69x91	6808 74x92	7425 75x99	8217 83x99

Table 2—Negative Multiplier Sequences

8100 Sequence							6000 Sequence									
1	4	8	15	3	11	9	6	3	10	6	5	2	4	1	6	2	7
3	11	5	5	15	11	1	8	3	3	4	10	1	8	7	2	4	3
5	13	15	12	6	2	1	1	2	2	4	1	6	6	1	5	2	6
7	15	17	6	11	15	9	1	8	4	4	3	3	4	12	2	1	1
9	17	7	2	5	7	12	4	6	1	3	6	2	3	2	1	3	10
11	8	2	4	2	10	1	2	9	3	3	4	4	1	8	1	4	3
13	2	4	6	4	4	7	2	6	5	6	8	5	8	5	3	4	2
15	4	6	1	4	2		12	3	1	6	7	7	2	1	5	4	
17	5	8	7	2	4		1	4	4	3	10	4	3	8	5	4	
9	1	10	10	2	6		11	2	2	11	1	4	9	2	2	2	
2	8	3	4	6	3		2	2	9	1	2	1	6	3	2	6	
4	10	9	8	10	5		10	2	9	1	2	6	4	1	4	2	
4	2	14	14	5	10		6	5	2	2	2	5	1	2	2	1	
2	10	16	1	7	6		5	1	6	8	6	8	3	1	1	3	
8	14	15	15	14	4		1	8	1	4	8	3	2	1	7	7	
10	16	1	10	2	2		3	3	6	2	1	1	1	2	4	3	
12	16	2	4	14	14		3	1	4	1	4	1	1	6	2	4	
14	1	1	1	11	3		2	4	3	1	5	9	3	2	5	7	
16	1	5	3	2	13		3	2	8	3	2	3	5	7	6	3	
17	2	7	5	1	12		1	2	8	5	8	3	7	3	2	2	
1	5	7	7	3	1		1	10	4	4	2	10	1	1	3	3	
3	7	2	8	1	3		2	2	2	2	4	2	2	5	6	1	
5	6	11	1	4	2		9	8	2	1	4	4	3	6	4	3	
7	3	9	11	7	3		4	4	1	2	6	1	3	6	5	2	
5	11	4	10	9	7		4	1	1	2	4	1	3	8	3	3	
7900*	7708	7520	7350	7200	7040	7000	5896	5795	5694	5605	5490	5394	5301	5200	5112	5032	5000

*Number is 8100 (or 6000) minus the sum of all the preceding negative multipliers. It will register in the calculator if all the multipliers in a column are entered correctly.

41 and 71. These factors then can represent the numbers of teeth on two of the four gears.

STEP 6: A listed integer obtained from the product dial defines the numerator of the decimal ratio. Read the denominator from the other dial of the calculator. It, too, is a product of two whole numbers and therefore suitable for numbers of teeth on two more gears. Read these tooth numbers also from Table 1.

The 7998 reading on the other dial, concurrent with the 2911 portion on the product dial, has factors 86 and 93, Table 1. Thus, the four gears in the combination and the ratio they give are

$$\frac{2911}{7998} = \frac{41 \times 71}{86 \times 93} = 0.3639\ 6599$$

which differs from 0.3639 7023 by − 0.0000 0424.

Alternative Procedures

In the foregoing example, 14 negative multipliers are used. Forty is probably more nearly the average in engineering practice. Over 100 may be required around 10 per cent of the time.

In case the 8100 sequence does not yield an acceptable combination after a hundred multipliers are used, it is advisable to switch to the 6000 sequence, Table 2. Clear the dials, excepting the decimal ratio locked in the keyboard, and multiply by 6000.

For the 6000 sequence, the decimal number to watch for on the product dial is smaller than 0.025 or greater than 0.975 because the limits for this sequence are ±0.025. In all other respects, the procedure is the same as in Steps 4 to 6.

To prepare additional sequences of negative multipliers is easy. For instance, a 10,000 to 9000 sequence may prove worthwhile if low decimal ratios are encountered often. Consider the 8100 sequence for illustration: From Table 1, 8100 − 8099 = 1, the first negative multiplier in Table 2; 8099 − 8096 = 3, the second negative multiplier; 8096 − 8091 = 5, the third; and so on.

Limitations

The tabular values are easily extended beyond the 8217 product to provide pairs of gears with greater numbers of teeth if needed.

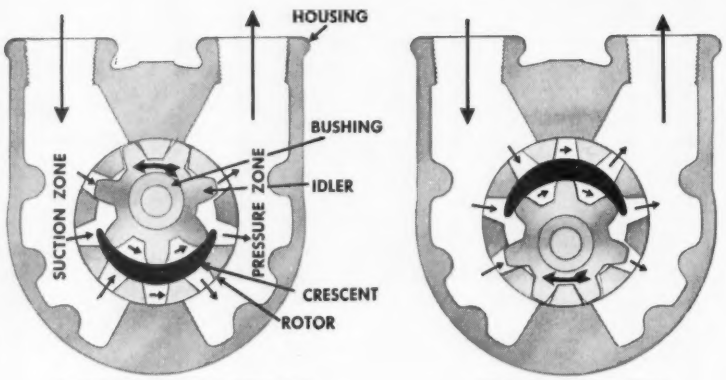
When an accuracy of ±0.000 0025 (or closer) in the ratio is required, one of the other many methods employing continued fractions or conjugate fractions is recommended. In these cases, it is helpful to allow six gears (three pairs) in the train.

In the routine problems that come up day after day, the solutions offered by the method described here are usually satisfactory.

The TUTHILL Internal Gear Pump... and its advantages in reversing applications

by E. H. Schanzlin,
Chief Engr., Tuthill Pump Co.

Extremely high reliability, proven in thousands of applications over a 30 year period, has made Tuthill's Internal gear pump an industry standard. The Internal gear construction particularly adapts itself to reversing pump applications as indicated in the sketches at right.



How It Operates

Key elements are the rotor, idler gear and the crescent shaped partition. This crescent shaped partition, shown in heavy black, is cast integral with a moving part called the idler carrier.

In the drawing at left, power is applied in counterclockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the rotor is sealed by the crescent. When the pump is started, there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

When shaft rotation is changed from counterclockwise to clockwise, as in the drawing at right above, the idler carrier, (including the idler gear and crescent) automatically rotates 180° through the suction zone. This changes the directional flow within the pump without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that the crescent can rotate only 180° —always through the suction zone. If rotation were again reversed to counterclockwise, the crescent would swing back to its original position (shown at left above).

No valves required . . . ports remain constant

This unique construction permits positive reversing action, without any valves, and with the port positions remaining constant. In addition Tuthill's reversing pumps provide all the other attributes of internal gear construction . . . extremely high reliability, compactness, and high efficiency.

Reversing Pumps with internal gear construction pay particular dividends on applications where the pump must be driven from a reversing shaft or when machinery must be shipped without knowing the ultimate direction of the driving unit.

375 reversing pump models

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Circle 472 on Page 19

Operating principles and recommended design practices for

Pneumostatic Bearings

V. H. McNEILLY
E. I. du Pont de Nemours & Co.
Wilmington, Delaware

BEARINGS lubricated by a film of compressed air have many important and varied applications. Attractive characteristics of pneumostatic bearings include: Low friction, even at a standstill; wide operating-speed range, limited only by the bursting strength of rotating members; immunity to temperature extremes; positional accuracy down to microinches.

"Pneumostatic" means "hydrostatic air," that is, a hydrostatic bearing using compressed air rather than oil or water as its working fluid. The principles of operation are essentially the same as for hydrostatic bearings which use incompressible fluids, but additional considerations must be given to expansion of the fluid, critical flow velocities, and vibration problems associated with compressibility.

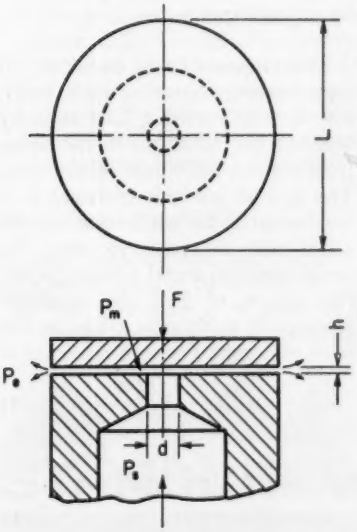

Fig. 1—Single-hole circular thrust bearing, the basic element for design of pneumostatic bearings with inherent orifice compensation.

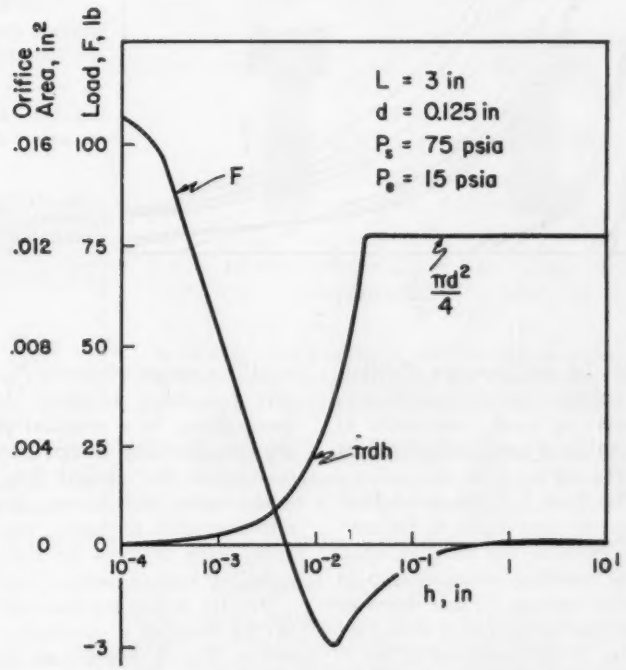

Fig. 2—Representative plot of load variation over extreme range of clearances for bearing of Fig. 1.

Single Thrust Disc: Consider first the simple thrust bearing, Fig. 1, consisting of two parallel circular discs separated by a uniform gap through which air flows radially outward. For effective bearing operation, the force F (and, therefore, pressure P_m) must increase as the gap h is decreased. This will be the case as long as there is a pressure drop from the fixed supply pressure P_s to a lower pressure P_m. A decrease in h increases P_m due to decreased air flow.

Necessary flow restriction may be provided by either a capillary tube or small orifice from which the air flows into a small intermediate pool and then into the gap, or by the annular orifice formed at the junction of hole d and gap h, Fig. 1. This general configuration is called the "inherent orifice" type.

Variation of F with h over a wide range of clearances for a particular bearing of this type is shown in Fig. 2. At extremely small values of h the flow of air is so small that the pressure drop in the orifice is negligible. As long as pure viscous flow

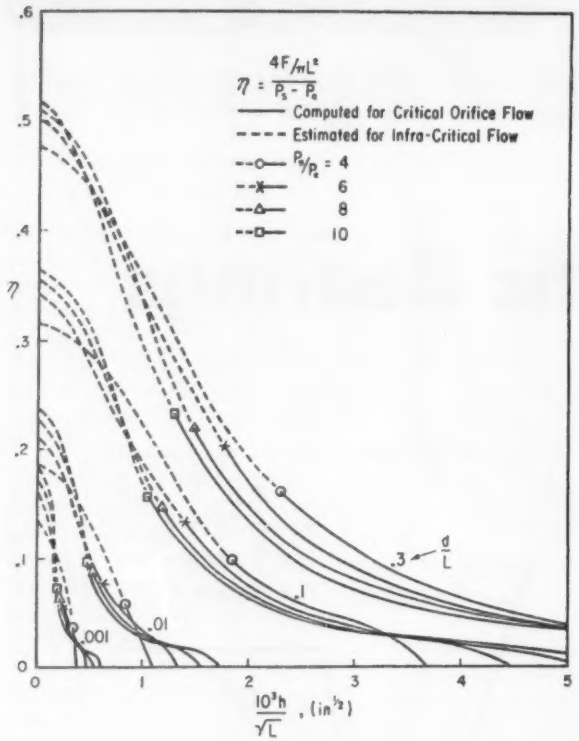

Fig. 3—Pressure efficiency of a single-hole circular air-thrust bearing. This chart and Equation 2 are the basic tools of bearing design.

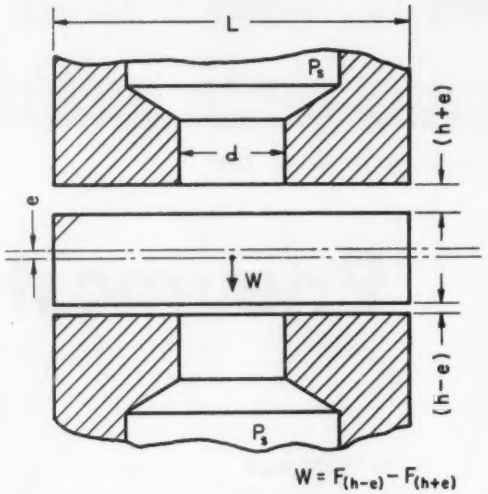

Fig. 4—Opposed thrust discs acting on one movable member.

exists in the gap, pressure distribution is independent of gap h. Hence, the curve for total load starts at zero slope at a load determined by setting $P_m = P_s$.

In Fig. 2, as h is increased from 10^{-4} in., the load begins to decrease. This is because the flow increases and the resulting pressure drop in the orifice reduces P_m and therefore F. The load continues to drop rapidly due to the combined effect of decreasing P_m and changing pressure distribution in the gap. Flow in the orifice soon reaches sonic velocity. In Fig. 2, this flow condition occurs at approximately $h = 10^{-3}$ in. At $F = 0$, the partial vacuum under a portion of the bearing balances the positive pressure under the remainder. The vacuum is increased further if the gap is forcibly increased. The net force changes back to a very small positive value due to the impingement of the high-velocity jet on the center portion of the disc. The region of interest in bearing design is the positive-force region at the left in Fig. 2.

The point of maximum stiffness, or highest spring constant, occurs at a gap slightly less than that at which the orifice flow becomes "choked" due to sonic velocity. This condition occurs whenever $P_m/P_s \leqq 0.53$ (assuming adiabatic flow in the orifice). As a practical procedure for obtaining design curves, it is assumed that choked flow exists in the orifice and the resulting flow rate is equated to that in the clearance space to solve for the corresponding load capacity.

Results of this solution are given in the form of a composite set of curves, Fig. 3. Here, load capacity is represented by over-all pressure efficiency,

$$\eta = \frac{\frac{4F}{\pi L^2}}{P_s - P_e} \qquad (1)$$

where L = diameter of thrust disc and P_e = exit pressure (absolute).

These curves are based on the assumption that any recovery of velocity head that occurs, associated with orifice discharge, is included in the intermediate pressure, P_m, and the discharge coefficient which is taken as 0.76. Also, standard atmospheric conditions are assumed for viscosity, density, and exit pressure calculations. On this basis, then, the equation of choked orifice flow reduces to

$$Q_1 = 75{,}000\, h d P_s \qquad (2)$$

where d is the diameter of the feed hole into the bearing.

Equation 2 may be assumed to hold throughout the range of the curves in Fig. 3. In the region of the dashed curves, this equation provides an upper limit, since the actual flow will be less than the critical value. This equation and Fig. 3 thus provide the only tools needed to select bearing proportions for a given application.

Two Opposed Discs: Consider two such bearings opposing each other, Fig. 4. The resulting load capacity becomes the difference in the forces from the two individual thrust units. The gap on one side increases to a maximum of $2h$ while that on the other side decreases to zero. To avoid metal-to-metal contact, a deflection, e, of half the available distance is arbitrarily taken as the basis of design. Pressure efficiency is

$$\eta_{h/2} - \eta_{3h/2} = \frac{4W}{\pi L^2 (P_s - P_e)} \qquad (3)$$

where W is the design load. From Equation 2, then, total flow is

$$Q_2 = 150{,}000\, h d P_s \qquad (4)$$

Total flow is independent of deflection e, Fig. 4, because the increase in flow on one side is com-

FASTENEERING

TIPS ON FASTENER APPLICATIONS BY **STANSCREW**

Coarse Threads . . . Fine Threads . . . Which One . . . When?

What's the difference?

Coarse threads conform to Unified National Coarse (UNC) standards while fine threads are governed by Unified National Fine (UNF) standards. Both include precise, detailed specifications for all thread dimensions and proportions.

UNF standards specify substantially more threads per inch. The following table illustrates the range of difference in various diameters.

Diameter of Fastener	UNC Threads Per Inch	UNF Threads Per Inch
¼″	20	28
⅜″	16	24
½″	13	20
¾″	10	16

Coarse thread advantages

For the great majority of applications, fasteners with coarse threads are used because of these advantages:

1. They assemble easier and faster . . . provide a better start with less chance of cross threading.
2. Nicks and burrs from mass handling are less liable to affect assembly.
3. More clearance provided for plating.
4. Less liable to seize in temperature applications and in joints where corrosion will form.
5. For threading into lower strength materials, coarse threads are less prone to strip.
6. Extreme difficulties are encountered in attempting to tap fine threads in brittle or friable material.

Fine thread advantages

In some applications, fine threads provide a superior solution because of these advantages:

1. They are some 11% stronger than coarse threads due to greater cross-sectional area.

Two ⅜″ x 1″ socket cap screws. Coarse thread (UNC) has 16 threads per inch; fine (UNF) thread 24.

2. In very hard materials, fine threads are easier to tap.
3. They have better fatigue life than coarse threads.
4. They can be adjusted more precisely when a cotter key is used.
5. Where the length of engagement is limited, where a smaller lead angle is required, or where the wall thickness requires a smaller thread, fine threads should be used.

Don't overload inventory

In trying to establish the best possible fastener for each application, don't stock too many fasteners and overload your inventory. A good rule of thumb is "one thread for a given size and grade of fastener" . . . choosing the type of thread which is best for all applications involving that size and grade. In many cases this will boil down to a coarse thread, since the group will probably include a tapped hole in a friable or low strength material.

For further information

For more detailed information, or the answer to a specific problem, call in your Stanscrew fastener specialist. He is quickly available through your local Stanscrew distributor . . . also your source for Stanscrew's complete line of over 5,500 different types and sizes of dependable fasteners.

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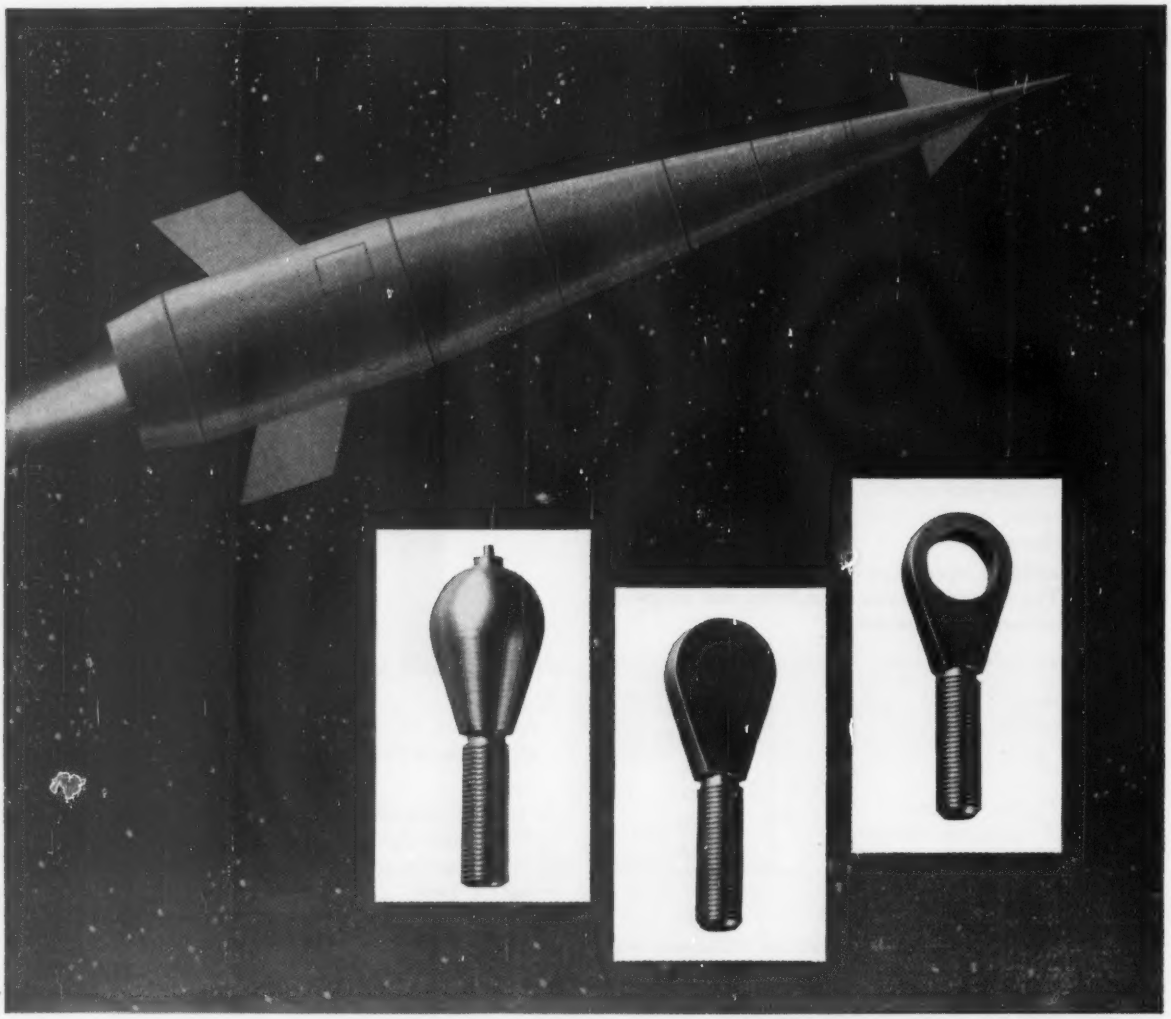
STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 473 on Page 19



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Carpenter Steel of New England, Inc., Bridgeport, Conn.

pensated by the decrease on the other.

Complete Journal Bearing: A complete journal bearing can be designed by proportioning a layout of holes to approximate radially outward symmetrical flow. Four or more holes are preferred. Number and arrangement of holes is best determined by sketching a developed view of the bearing surface and choosing a bearing diameter, D, and over-all length l, Table 1, so that

Table 1—Recommended Hole Layout for Pneumostatic Bearings

Bearing Ratio l/D	Rows of Holes l/L	Holes per Row	Total Holes n
0.1	1	30	30
0.5	1	6	6
1.0	2	6	12
1.5	2	4	8
2.0	3	5	15
2.5	3	4	12

they are integral multiples of a length that corresponds to L. In multiple-hole arrangements, L represents the length of journal bearing fed by one row of holes.

Load capacity may be estimated by assuming that each pair of opposed pads acts the same as flat circular discs. Equation 3 gives the load capacity of the bearing in Fig. 4 regardless of whether the central member is flat or cylindrical. When more than two opposed pads are used, the total load is $n/2$ times the load from Equation 3 where n is the total number of holes.

ASLE Paper No. 60AM 5A-2, *"Design and Use of Pneumostatic Bearings," presented at the 15th ASLE Annual Meeting, Cincinnati, April,* 1960, 16 *pp.*

bearings

Performance of Heavily Loaded Oscillating Roller Bearings Up to 600 F

W. A. Glaeser, Battelle Memorial Institute

Behavior of oscillating bearings at elevated temperatures, and load-life characteristics determined through statistical analysis of failure data. Operating temperatures of 300, 450, and 600 F were imposed. Bearing materials investigated included AISI 52100 steel, M-2 tool steel and 440-C stainless steel. Grease lubrication was used. The bearing load range included 250,000 to 500,000 psi maximum Hertz stress. For temperatures to 450 F, AISI 52100 steel proved satisfactory. Tool steel (M-2) and 440-C stainless steel proved satisfactory for temperatures to 600 F. Although failure modes were predominantly by plastic deformation, wear, and oxidation, failure distribution frequencies fit the Weibull distribution commonly used in bearing fatigue studies. Data scatter was less than that expected for continuously rotating ball bearings.

ASLE Paper No. 60AM 3C-2, *"The Performance of Heavily Loaded Oscillating Roller Bearings from 300 to 600 F," presented at the 15th ASLE Annual Meeting, April,* 1960, 11 *pp.*

materials

Properties of Forgings of Nickel-Chromium-Iron Alloy

C. L. Dotson, assistant chief metallurgist, and R. L. Roshong, chief metallurgist, Cameron Iron Works Inc.

Attainable strength levels of Inconel in heavy, forged sections. Mechanical properties of Inconel forgings can be controlled to a significant degree by proper die design, by selection of thermal conditions during forging, by controlled thermal cycles after forging, and by varying the carbon level of the alloy. Ultimate-strength levels as high as 90,000 psi and yield-strength levels as high as 45,000 psi can be consistently and uniformly produced in heavy forged sections. Forgings of many geometrical configurations can be produced with uniformly higher tensile strengths.

ASME Paper No. 60-MET-5, *"Nickel-Chromium-Iron Alloy (Inconel) Forgings for Nuclear-Reactor Systems," presented at the ASME-AWS Metals Engineering Conference, Los Angeles, April,* 1960, 7 *pp.*

Ceramic Coatings for High-Temperature Service

S. W. Bradstreet, supervisor, Inorganic Technology, Armour Research Foundation.

Types of ceramic coatings for service in extreme thermal environ-

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MACHINE DESIGN

ments. To protect its substrate (surface being coated) in a thermal environment, a ceramic coating must conform to, adhere to, and insulate the substrate.

Conformity involves "wetting"—the electromagnetic attraction of a liquid to a solid surface. Adherence is the ability of a composite coating to withstand certain applied stress without separation or failure.

Where protection against heat alone is needed, the coating must be insulative. Listed according to temperature service, low to high, protective coatings are: Porous, dense, duplex, and ablative. It is noted that there may be a positive disadvantage in the use of any of these coatings when it is exposed to higher (and, in some instances, to lower) temperatures than those for which it is intended.

The most challenging areas for coating development at present are in the field of "high-temperature elements" — niobium, tantalum, molybdenum, tungsten, graphite.

NACE paper, "Ceramic Coatings for High-Temperature Service," presented at the NACE 16th Annual Conference, Dallas, Texas, March, 1960, 8 pp.

Energy vs. Stress Theories For Combined Stress

W. N. Findley, professor of engineering, Brown University; E. Szczepanski, student, Brown University; P. N. Mathur, research engineer, Gas Turbine Dept., Ford Motor Co.; and A. O. Temel, instructor of engineering, Robert College.

Evaluation of theories governing fatigue failure under combined stresses. Because fatigue cracks are produced in regions in which the strain energy is essentially constant, it is evident that fluctuating strain energy can not be the prime cause of fatigue failure. While strain-energy forms of expressions may be useful as design formulas for combined stress, experiment seems to prove that they are not valid for describing the mechanism of fatigue. Hence, their use for describing fatigue under states of combined stress beyond the range which has been verified by experiment may yield incorrect results.

ASME Paper No. 60-MET-1, "Energy Versus Stress Theories for Combined Stress —A Fatigue Experiment Using a Rotating Disk," presented at the ASME-AWS Metals Engineering Conference, Los Angeles, April, 1960, 8 pp.

techniques

Using Numerical Controls

Charles E. Chapman, manufacturing engineer, Controls—Flight Propulsion Div., General Electric Co.

Experience and decisions in the design and use of numerical controls for machine tools. Selection of systems has been based on such requirements as high accuracy, small lots, and frequent design improvements. One machine has an IBM punched-card input. Thirteen other machines use a one-inch punched-tape input and all have the same tape code.

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ASTME Paper No. 283, Vol. 60, Book 1, "Numerical Controls—How We Use Them," presented at the 28th Annual Meeting, Detroit, April, 1960, 9 pp.

lubrication

High-Temperature Lubrication In Reactive Atmospheres

Robert L. Johnson, Max A. Swikert, and Donald H. Buckley, Lewis Research Center, NASA.

Friction and wear experiments show the interaction of various atmospheres, lubricants, and materials, at temperatures to 1500 F. An effective lubrication method, based on surface film formations from reactive gases, can be obtained. Cobalt-base and nickel-base alloys, sliding in a lubricating atmosphere of bromine and fluorine-substituted methane or ethane derivatives, form low-shear-strength bromine compounds. Optimum reaction characteristics will provide low friction and wear, but the possible incidence of corrosive wear because of excessive reactivity remains a critical problem.

NACE paper, "High-Temperature Lub-

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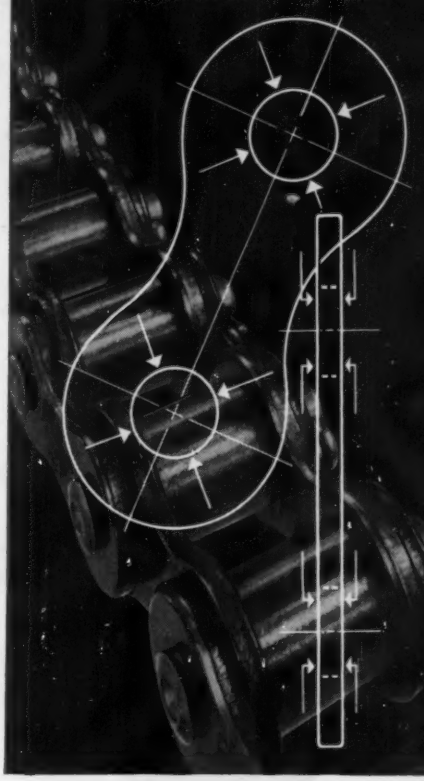
FIGHTS FATIGUE



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8-page folder describes these and other Lamb Electric motors.

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SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 478 on Page 19

rication in Reactive Atmospheres," presented at the NACE 16th Annual Conference, Dallas, Texas, March, 1960, 10 pp.

mechanical

Maintainability Numerics For the Design Engineer

M. P. Feyerherm and H. W. Kennedy Jr., Radio Corp. of America

Derivation of numerics which guide the equipment designer and user. Numerics enable comparisons between the relative maintainability of various equipment designs. One numeric of importance to the design engineer is the expression of the average time required to repair an equipment failure. The design engineer can do much to minimize this figure. One factor to be considered is the accessibility and ease of replacement of parts. This matter is particularly important with high failure-rate parts. Proper design packaging will place high failure-rate parts in the most accessible locations, and provide for easy replacement. Another design consideration is proper selection and placement of test points so that test time is minimized. A numeric which is of particular significance in design gives the ratio of required repair time to the operating time of the equipment.

"Practical Maintainability Numerics," presented at the Sixth National Symposium on Reliability and Quality Control, Washington, January, 1960, symposium proceedings pages 343 to 346.

Selection and Application Of Temperature Controls

Harold G. Payne, manager, Measurements Group, Foxboro Co.

Pros and cons in the measurement of temperatures by filled thermal systems, resistance bulbs, and thermocouples. Also, positioning of the final operator at a physical distance from automatic controllers of pneumatic, electric, and electronic types.

Filled systems are derivations of the earliest thermometers and generally consist of a sensing bulb connected through capillary tubing to an expansible element sensitive to changes in pressure or volume. Vapor pressure systems are the least expensive because they are the simplest mechanically. They are inherently accurate and generally the fastest responding. However, characteristic nonlinear outputs make it awkard to combine multiple measurements on one chart.

Gas systems can measure the widest range of temperatures of all filled systems. Gas thermometers perform best as wide-range devices between 300 to 1000 F.

Above 600 F, mercury systems are the smallest size filled systems.

Liquid-expansion systems offer uniform calibration, applicability to measurement of ambient temperature range, and small bulb size.

"Temperature Controls—Selection and Application" presented at the Fourth Conference on Manufacturing Automation, Purdue University, April, 1960, pp. 76 to 83, collected conference papers.

Planning for Maintenance During Product Development

R. I. Moeller, staff engineer, Maintainability Engineering, International Business Machines Corp.

How a development engineering organization co-ordinates maintenance planning during product development.

"Co-ordination of Maintenance Planning during Equipment Development," presented at the Sixth National Symposium on Reliability and Quality Control, Washington, January, 1960, symposium proceedings pages 331 to 334.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; paper 35 cents to members, 50 cents to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

ASTME—American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave., Detroit 38, Mich.

Fourth Conference on Manufacturing Automation, collected papers available from *Automation*, Penton Publishing Co., Penton Bldg., Cleveland 3, Ohio, price 2 dollars.

NACE—National Association of Corrosion Engineers, 1061 M & M Bldg., Houston 2, Texas.

Sixth National Symposium on Reliability and Quality Control, Proceedings available from Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y., 578 pp., price 5 dollars.

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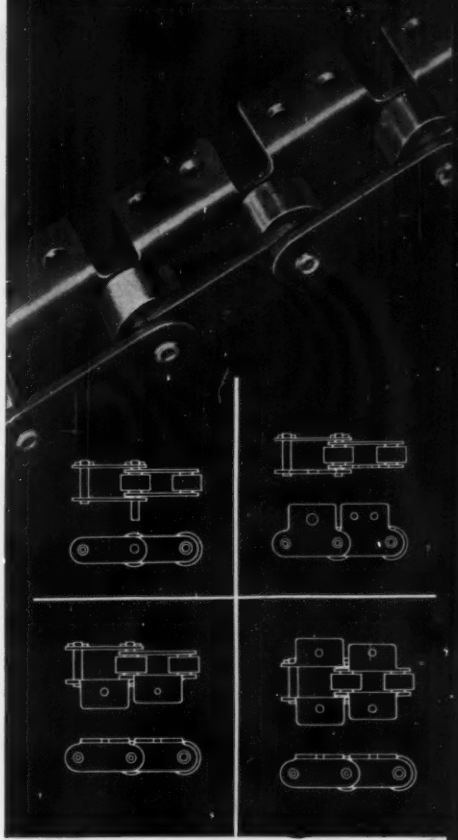

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Circle 479 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Stainless-Steel Wire

Technical data and practical information about using and ordering stainless-steel wire are provided in illustrated Wire Manual. It includes data on the chemical analyses and mechanical properties of all grades of stainless steel used in wire, and recommendations for the application of representative grades in almost 400 corrosive environments. Section outlining uses of stainless-steel wire also gives guides for ordering wire for each use. 22 pages. Jones & Laughlin Steel Corp., Stainless & Strip Div., Box 4606, Detroit 34, Mich.

Circle 601 on Page 19

Axial Fans

Comprehensive two-color catalog contains over 65 different flow charts, electrical specifications, and dimensions on axial-type fans. Units cover a range of frequencies from 60 to 1000 cps with free-air ratings from 27 to 960 cfm. One page is devoted to the proper method of selecting a fan. Important information on construction, rotation, leads, lubricants, and insulation class is also given. 16 pages. Air-Marine Motors Inc., 369 Bayview Ave., Amityville, L. I, N. Y.

Circle 602 on Page 19

Molded Plastic Products

New booklet, Form 909, describes molded Formica products for a wide range of industrial applications. Complete molded products service is outlined, including design of parts, design and fabrication of molds, and molding of parts to specifications. Properties of 25 Formica laminates available in molding grades are listed, and photographs show typical applications. 8 pages. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio.

Circle 603 on Page 19

Rack and Panel Connectors

DTD series connectors are described and pictured in Form DTD-100-60. Single and dual series are depicted. Information on materials and specifications, shell dimensions, mounting data, insert arrangements, and ordering is provided. 2 pages. Burndy Corp., H. H. Buggie Div., P. O. Box 817, Toledo, Ohio.

Circle 604 on Page 19

Unions and Valves

Revised Catalog 60 contains complete engineering data, sizes, weights, and dimensions on Perfect Seal pipe unions and swing check valves. Information on gasketless cup-orifice unions and ductile-iron check valves is included for the first time. 20 pages. Catawissa Valve & Fittings Co., Catawissa, Pa.

Circle 605 on Page 19

Electronic Capacitors

Bulletin GET-3032 provides detailed information about a wide range of standard commercial, MIL-C-25A, and Permafil capacitors used for ac-dc applications such as blocking and bypass service, power-supply filters, and others. Publication contains graphs, tables, outline drawings, quotation guide forms, description of units, and application information. Complete rating and dimension tables are included for applications ranging from 100 to 50,000 v dc and from 236 to 660 v ac. 28 pages. General Electric Co., Schenectady 5, N. Y.

Circle 606 on Page 19

Molded Packings

Catalog and price list MP 160 provides information on V-type packing, the Palmetto Pyramid. Individual descriptions of the U-ring, Kup, and Pisto-Ring packings are furnished. Each type of molded packing is illustrated and listed with comprehensive descriptions of construction and specific use. One-page applications chart aids choice of correct type of molded packing for a particular type of service. 8 pages. Greene, Tweed & Co., North Wales, Pa.

Circle 607 on Page 19

Solid-State Conversion

New brochure, "Solid-State Conversions," provides information on advancements in new systems and components, particularly in size reduction and extended environmental range, as made possible by the use of solid-state techniques. Voltage level sensing systems (ac and dc), static inverters, power supplies, ice-detection systems, and solid-state components are discussed. About 28 pages. Cook Electric Co., Diaphlex Div., 2700 Southport Ave., Chicago 14, Ill.

Circle 608 on Page 19

Recording Supplies

Folder 2950 describes chart papers, writing styli, and other supplies for all Brush direct-writing recording equipment. Booklet contains samples of chart papers. Typical recording traces in the three basic techniques—ink, electric, or thermal—demonstrate the uniformity, clarity, and reproducibility to be expected. Pens and styli for each mode of recording also are illustrated and described. Model number tabulations of chart papers and styli for all existing Brush oscillographs and operations monitors, including BL series, are included. 4 pages. Clevite Corp., Brush Instruments Div., 37th and Perkins Ave., Cleveland 14, Ohio.

Circle 609 on Page 19

Limit Switch

Illustrated Bulletin EC-SL260 describes and pictures SL-2 snap-lock limit switch. Subjects covered include key design features, how the unit operates (aided by a series of progressive colored illustrations and line drawings), switch specifications, parts lists, actuating cams, and operating levers. Also included are information and illustrations of rotary-action and maintained-contact models. 16 pages. National Acme Co., Electrical Controls Div., 170 East 131st St, Cleveland 8, Ohio.

Circle 610 on Page 19

Temperature Controls

Simple, inherently stable temperature-control packages, Simplytrols, applicable to a variety of industrial processes, are described in Bulletin 108. Bulletin explains operation, circuitry, and safety features of three basic types of thermocouple-actuated units, including proportioning model that holds temperature to ±1 F of set point. Other types are manual reset and automatic on-off controls. 12 pages. Assembly Products Inc., Chesterland, Ohio.

Circle 611 on Page 19

Seamless Tubing

Bulletin 60 describes manufacturing capabilities of fine seamless tubing from a broad range of ferrous and nonferrous metals and alloys. Sizes from 0.005-in. OD, wall thicknesses, and tolerances are listed, as well as properties and applications of various alloys. Fabrication service for the production of precision tubular parts to specifications is described. 12 pages. Uniform Tubes Inc., Collegeville, Pa.

Circle 612 on Page 19

Industrial Thermometers

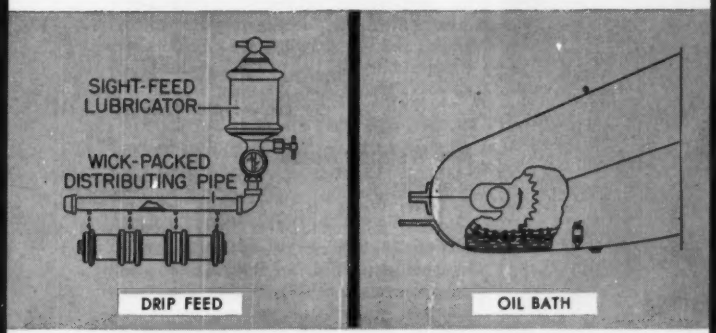
Bulletin F 1 contains information on a line of industrial thermometers available within −120 to +120 F temperature limits. Contents includes material on test wells, thermometers with fixed hex connections, and on the various forms available. 4 pages. Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.

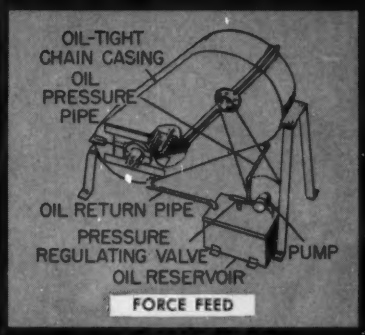
Circle 613 on Page 19

the BIG PLUS value...

Pace-Setting Research and Development

Research Shows Lubrication Has 300-to-1 Effect on Chain Life



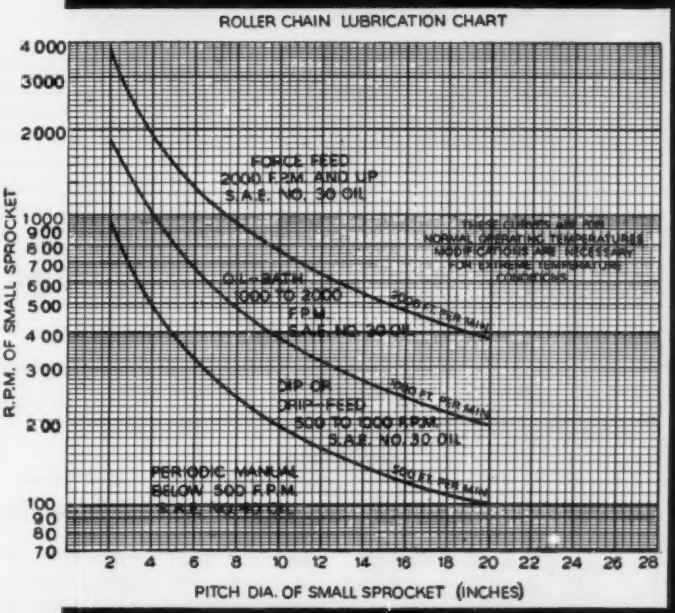


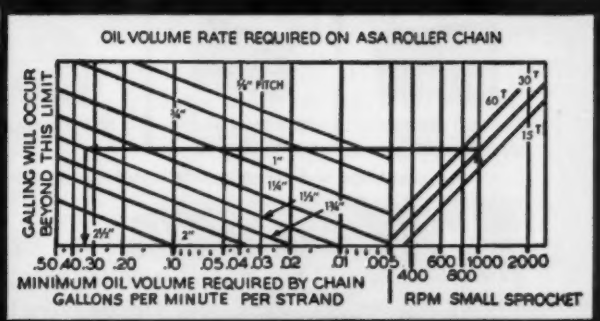
How important is correct lubrication to the life of a chain drive? Recent research by CHAIN Belt engineers has conclusively demonstrated that a difference in chain wear life of as much as 300 to 1 can be experienced on the same drive, depending upon the lubrication it receives. Extensive testing shows that merely getting oil on the chain does not assure good lubrication. The amount of oil reaching the chain is also important: not only must it be sufficient to maintain a lubricating film within the chain joint, it also carries out an important function as a coolant. A lubricating method must therefore be used to permit the oil to reach the joint in sufficient quantity.

The type and amount of lubrication required for a drive are related directly to the pitch diameter and r.p.m. of the smaller sprocket in the drive. The two lubrication charts illustrated above have been prepared by CHAIN Belt engineers to provide a guide to correct lubrication. They will assure maximum drive life in all normal drive conditions.

There are many applications where special techniques and lubricants are required. Extreme temperatures... applications where petroleum-base lubricants cannot be used...exposed drives where moisture or abrasive conditions are encountered... must be individually considered to assure maximum chain life.

Through their complete research program, CHAIN Belt engineers have gathered basic data on lubrication for virtually every type of condition. If you are concerned about the correct lubrication of your drives...if you have special problems...may we suggest you contact your local Rex District Sales Engineer. Or write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis., giving complete details of the drive and operating conditions.





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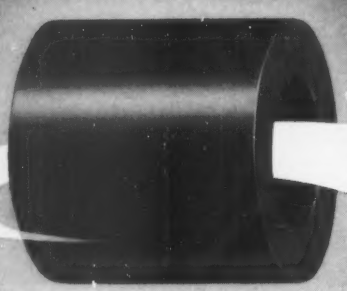
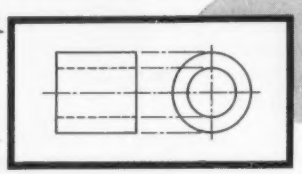
Circle 480 on Page 19

HYDRO-AIRE specifies MORGANITE

—for extra reliability in *hytrol* anti-skid braking systems!



Hytrol Anti-Skid Braking Systems, a development of Hydro-Aire Company, are widely used on fighters, bombers, commercial transports and surface vehicles. Self-lubricating Morganite components are employed in these systems because of their smooth-functioning, reliable performance. Another example of Morganite's ability to meet today's critical requirements.



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Circle 481 on Page 19

Gearing System

Descriptive pamphlet AD-68 introduces Helicon gearing system which offers low cost yet a high degree of insensitivity to mounting errors. Gears are applicable through ratio range from 3:1 to 400:1. Complete description of gears and system relation to other types of face gearing is included, as well as manufacturing processes and design details. Many photographs and line drawings are incorporated. 8 pages. Illinois Tool Works, Spiroid Div., 2501 N. Keeler Ave., Chicago 39, Ill.

Circle 614 on Page 19

Arc Welding Guide

Booklet EW-213, "Vest Pocket Guide to Better Welds," a 6½ x 3¾-in. booklet, provides information on five essentials for proper welding procedures, examples of good and bad welds, welding positions, operator qualifications, welding metals, steel available for welding, identification of metals, and causes and cures of common welding troubles. It also includes check points for quality welding, welding symbols, electrode cost data, safety precautions, definitions of welding terms, and types of joints. Eight factors to consider when selecting electrodes are enumerated, as well as electrode identification key, electrode selection, comparative electrode index, typical electrode deposition rates, automatic welding wires and flux, and welding power sources. 80 pages. Hobart Brothers Co., Troy, Ohio.

Circle 615 on Page 19

Choosing Laminated Plastics

Easy-to-use "Laminated Plastics Selection Guide" combines an informative manual with a quick-reference chart of characteristics for 21 commonly used laminate grades. Tables list tolerances for sheets, tubes, rods, and fabricated parts, and glossary of more than 40 commonly used terms is included. Chart of laminate characteristics assigns qualitative as well as quantitative values to the laminates listed. 12-page manual, plus wall chart. Taylor Fibre Co., Norristown, Pa.

Circle 616 on Page 19

Perforated Metals

Catalog 59 provides information on perforated metals for industrial applications. Advantages of perforated metals are listed, various metals which can be perforated are enumerated, and applications are given. Tables and pictures describe the various sizes and designs of perforations. 34 pages. Diamond Mfg. Co., Wyoming, Pa.

Circle 617 on Page 19

Diaphragm Seals

Bulletin 250 contains full descriptions, specifications, and prices of all models of Brookseal diaphragm seals. Seals protect pressure instruments against corrosion and clogging. 24 pages. Brooks Rotameter Co., P. O. Box 432, Lansdale, Pa.

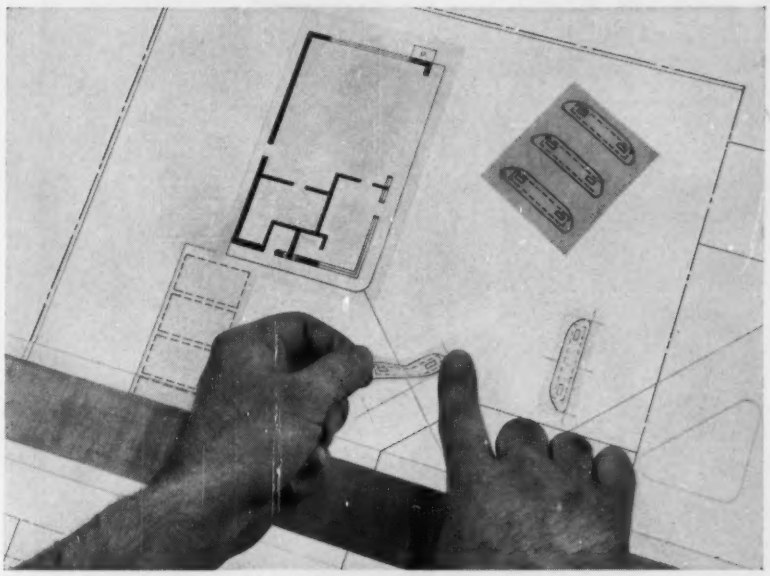
Circle 618 on Page 19

Low Cost Insurance Program Protects Original Drawings From Loss or Damage

Have you ever thought what would happen if your company's original drawings were lost or damaged? How much trouble and expense would be involved to replace them? Many companies are adopting a simple "insurance" program to meet just such a problem . . . a program which requires neither expensive new equipment or radical adjustments of established procedures. The program consists of two parts. First, recognizing the cost of *any* drafting medium is always an infinitesimal part of the investment in a finished drawing, the companies standardize on the drafting medium which affords their original drawings maximum life. Second, they institute the policy that original drawings must be used only as *masters*, that all printmaking must be done from *duplicate originals* of the masters.

The perfect answers to both these needs are Dietzgen polyester *drafting* film for all original drawings, and Dietzgen *diazo-sensitized* polyester film for duplicate originals! Dietzgen's polyester film is so tough it cannot be torn. Its crystal-clear transparency is permanent . . . never fogs or yellows. It's dimensionally stable; insensitive to temperature, humidity, acids or alkalines. The drawing surface of Dietzgen's polyester drafting film is unexcelled . . . accepts pencil or ink perfectly; erasures are smudge-proof and ghost-free. Inexpensive duplicate originals are quickly produced *in any desired quantity* by contact printing the original drawing on Dietzgen's diazo-sensitized polyester film. The images developed are *exact* duplicates of the original . . . uniform and permanent to provide the finest reproducibles attainable.

NEW PRINTED-ELEMENT DRAFTING TECHNIQUE CUTS DESIGN COSTS 66%



Printed-element drafting ends tedious redrawing of repeated elements . . . produces accurate reproducibles in record time.

The regional engineering office for a large oil company employed 15 draftsmen to prepare construction plans for new filling stations. Investigation of their drafting procedures revealed the majority of "board-time" was consumed redrawing, in varied combinations, the basic elements such as pump islands, hoists, and rest rooms, used in each station. Redrawing of the repeated station elements was tedious work and wasted valuable man-hours. Dietzgen solved this problem by recommending a new *printed-element* drafting technique utilizing Dietzgen's diazo-sensitized, adhesive-backed polyester drafting film. Duplicate originals of all repeated station elements are now printed on the Dietzgen film medium. The draftsman simply selects the proper elements for each station, mounts them on a sheet of Dietzgen polyester drafting film, and the plan is 75% complete without drawing a line! The finished drawing is a high-transparency reproducible, ready to produce any number of prints.

Today, five draftsmen handle the entire work load. The cost of station design has not only been slashed 66%, but the other ten draftsmen have brought the department's backlog down to a desirable level. Service to other departments has been greatly improved too; and rush jobs are handled on a basis never before possible.

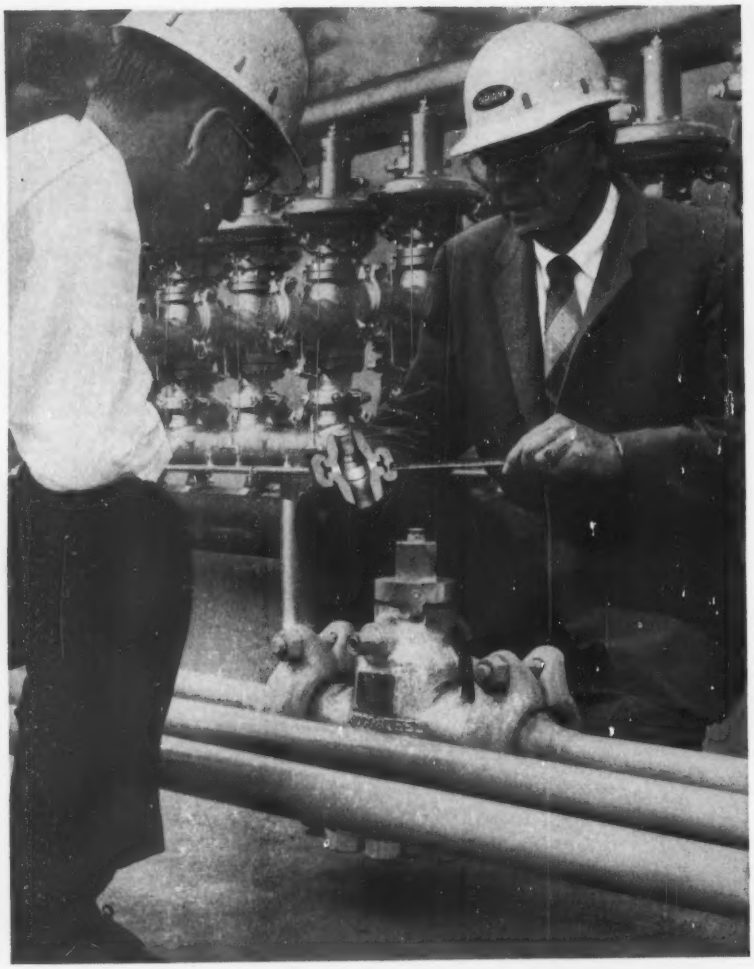
Printed circuits and plant layouts are other design activities where Dietzgen's *printed-element* drafting has been used with amazing cost-cutting, time-saving success.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-E160. Eugene Dietzgen Co., Chicago 14, Illinois

DIETZGEN

EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING



GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

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Circle 483 on Page 19

HELPFUL LITERATURE

Strain Gage

Type HTM monofilament, subminiature, wire strain gage is described in Product Data Sheet 4331. Gage measures in crevices, fillets, corners, keyways, gear teeth, and a variety of other applications, including high-temperature applications. Sheet also describes Type HTMI, a monofilament strain insert with ceramic insulators at lead ends. Line drawings, tables, and graphs add further data to both gage types. 2 pages. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

Circle 619 on Page 19

Welded Diaphragm Bellows

Design Guide 77BBP presents the story of welded diaphragm bellows from basic physics through applications. Guide includes drawings and specifications of the bellows, as well as specific illustrations of flexible, expansion, and pressure types. Included is a discussion of the differences between formed and welded bellows, the values of each, and their relative place in equipment design. 16 pages. Breeze Corporations Inc., 700 Liberty Ave., Union, N. J.

Circle 620 on Page 19

Plastic Products

Teflon, Raylon, and Kel-F products are described in Form 9703. Teflon products include gaskets, adhesives, bearings, coatings, hose, and packings. Properties, applications, and toxicology of Teflon are given, with graphs of helpful design properties. Raylon products include rods, tape, tubes, and machined parts. Discs, rods, sheets, and tubes of Kel-F are listed, and properties description and chart are included. 36 pages. Raybestos-Manhattan Inc., Plastic Products Div., Manheim, Pa.

Circle 621 on Page 19

Silicones for Electronics

New engineering guide, Form 10-126, explains how various physical forms of silicones contribute to reliability, miniaturization, modularization, and environmental protection; increase serviceability over wide extremes of temperature; and aid value engineering. Handbook contains engineering data and processing information on silicones, and details the important electrical and mechanical properties of the silicones most useful in electronics. It describes typical applications for silicones in every area of use. 12 pages. Dow Corning Corp., Midland, Mich.

Circle 622 on Page 19

Automation Components, Controls

Condensed Catalog D-31 provides information on timers and counters, heavy-duty industrial timers and counters, multi-circuit cam timers, electronic timers, and test equipment, switches, controllers, contactors, and valves. Pictures of all the units are provided, as well as list of specifications. 26 pages. Automatic Timing & Controls Inc., King of Prussia, Pa.

Circle 623 on Page 19

Speed Reducers

"Worm Gear Speed Reducers," Book 2824, introduces new line of fan-cooled worm-gear speed reducers in 25 types and over 135 sizes. They are available in ratios from 5:1 to 3600:1, with torque ratings to 135,000 lb-in. and horsepower ratings to 150 hp. Book is illustrated with many application photographs and lists equipment on which reducers are frequently used. Selection data include rating tables arranged according to speed as compared to ratio, with full complement of reducer sizes listed on individual pages for given rpm. Thermal input and mechanical output torques are shown for every speed and ratio for each reducer size. 66 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 624 on Page 19

Chromium-Nickel Stainless Steel

Series 300 Enduro chromium-nickel types of stainless steel are described in revised booklet Adv. 1124. Sufficient general information and technical data presented enable users of stainless to make correct design and buying decisions. Mechanical and physical properties at high and low temperatures are listed. 42 pages. Republic Steel Corp, Advertising Div., 1441 Republic Bldg., Cleveland 1, Ohio.

Circle 625 on Page 19

Variable-Speed Belts

Catalog VSB-1 provides information on sizes, ratings, and engineering data for variable-speed belts. Included is information on belt standards and much cross-reference data. Main features of the belts are described. 34 pages. Maurey Mfg. Corp., 2907-23 S. Wabash Ave., Chicago 16, Ill.

Circle 626 on Page 19

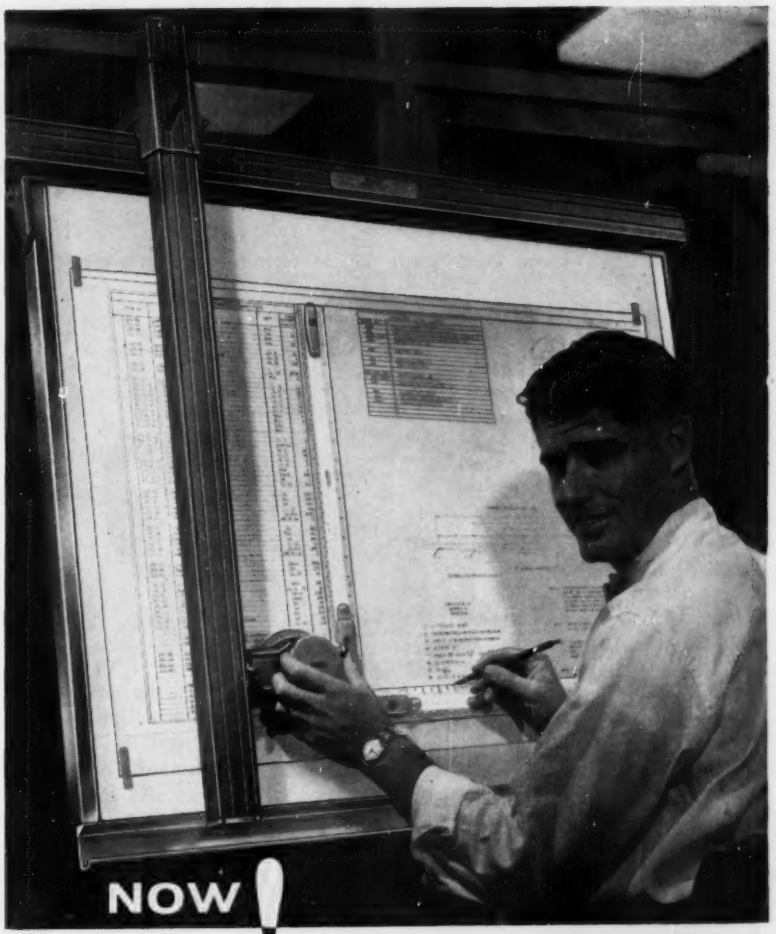
Reactive and Precious Metals

New pamphlet describes reactive and precious metal temperature characteristics and properties for nuclear and electronic applications. Also presented is information on the types of mechanical operations which can be performed on reactive and precious metals to convert them into wire, sheet, and special shapes of use in nuclear and electronic fields. 4 pages. Consolidated Reactive Metals Inc., 115 Hoyt St., Mamaroneck, N. Y.

Circle 627 on Page 19

Power-Transmission Equipment

Engineering Catalog D-60 describes all products in line of mechanical power-transmission equipment. Various sections are devoted to both new and established product categories, with engineering drawings, dimensions, weights, prices, technical data in tabular form, and many pages of helpful selection and application information. Separate section on general engineering data makes the book a handy reference manual on mechanical power transmission. 468 pages. Write on company letterhead to Dodge Mfg. Corp., Mishawaka, Ind.



● DRAFTSMEN CAN STRAIGHTEN UP AND DO BETTER, FASTER WORK!

Bruning's all-new Neoglide drafter literally puts draftsmen in a position to do better, faster work.* It provides complete maneuverability on any board *at any angle* without adjustment! Reinforced U-Beam construction offers amazing rigidity, strength, and accuracy. Yet resistance-free movement of the counterweight and vertical beam provide free-and-easy "floating" action. Touch-control protractor head gives automatic, pin-point angle selection. Mail coupon now to put yourself in a position to save time and money with all-new Neoglide!

*Study of 300 draftsmen showed 35% savings on drawing time—1/5 the backaches—on vertical or near vertical boards.

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Company_____
Address_____
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Circle 484 on Page 19

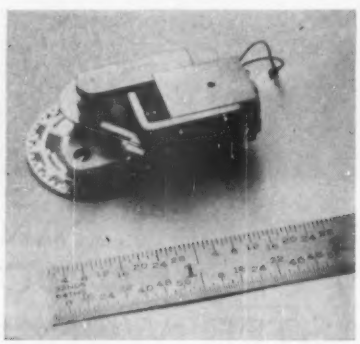
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Sequence Programmer

miniature unit operates with solid-state circuitry

Miniature, solenoid-actuated switching device to encode or decode events in a sequence employs an interchangeable coded disc to determine or sense the sequence of events. Designed for operation with solid-state circuitry over a wide range of input rates, unit has wide general application in complex automatic-control operations. Highly



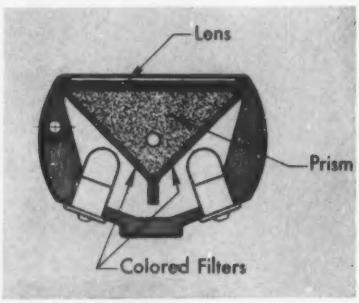
precise indexing action permits division of program disc for sequences requiring up to 100 switch positions. Complete programmer, including coded disc, is less than 1¾ in. long and weighs only 0.9 oz. It is rated for 4 to 8 v and operates with input pulses as short as 11 millisec up to 70 indexing motions per second. Environmental tolerance covers a temperature range from −40 to +165 F, and vibration at 10 g from 5 to 55 cps. **Elgin Micronics Div., Elgin National Watch Co.**, 366 Bluff City Blvd., Elgin, Ill.

Circle 628 on Page 19

Indicator Light

provide two different colored indications

Roto-Tellite two-color indicator light provides two different colored



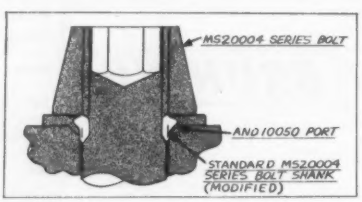
indications where the legend or function is common to both colors, such as a legend reading "fuel mixture" which illuminates green when operation is correct and red or amber when a malfunction occurs. This is accomplished by incorporation of a simple prism, shaped to produce an even, uniform light dispersion over the entire legend area. Unit features a rotating lamp capsule which permits simple bulb replacement without use of tools. Light is qualified to MIL-E-5272B and Bu Aer XEL-818. **Master Specialties Co.**, 956 E. 108th St., Los Angeles 59, Calif.

Circle 629 on Page 19

Bolt Head Seal

affords high-strength, high-pressure joint

Metal bolt head seal is available for installations where it is desired to attach a removable plate to a high-pressure vessel, necessitating the use of high-strength bolts. New seal has a heel wide enough to accept bolt tension preload, provides relief under bolt head, and a chamfer around



bolt hole. Installation (as shown) affords a high-strength, high-pressure joint capable of holding pressures to 10,000 psi at temperatures from −400 to +1800 F. **Harrison Mfg. Co.**, 739 N. Lake St., Burbank, Calif.

Circle 630 on Page 19

Decorative Plate Glass

reflects light in different ways

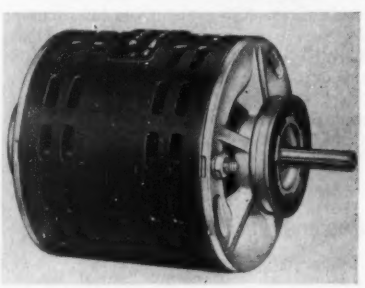
Galaxy glass, for application in product component design, is inscribed with diamond-shaped patterns of vertical and horizontal lines. It reflects light in different ways, according to the angle from which it is viewed. Glass can be fabricated in any flat shape, and lines can be printed in any color. **Lancaster Glass Corp.**, Lancaster, Ohio.

Circle 631 on Page 19

Small AC Motors

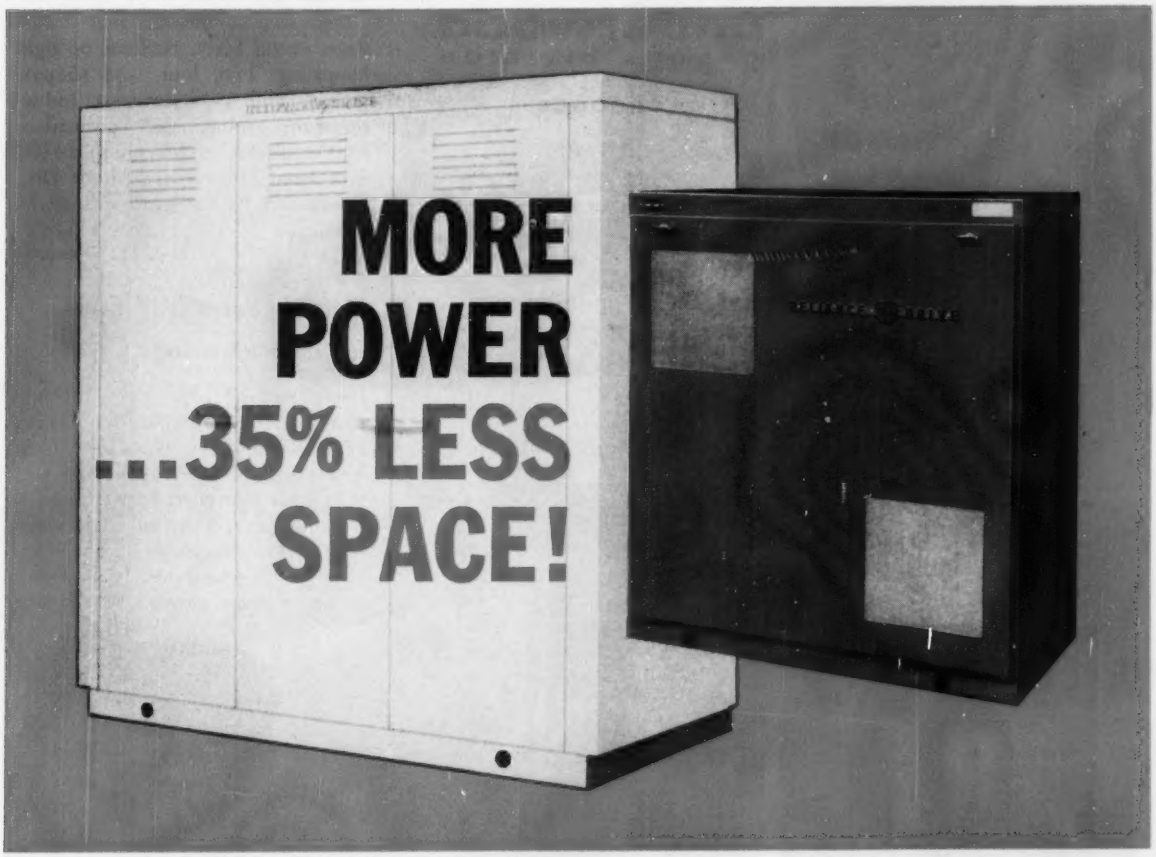
are furnished in 16 ratings from 1/100 to 1/3 hp

Line of small ac special-application



motors is available for office appliances, blowers, fans, small tools, and similar products where silent operation, limited mounting space, and minimum attention are desired. Sixteen horsepower ratings are furnished between 1/100 and 1/3 hp, based on open-ventilated operation, 40 C rise, constant speed, and con-

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

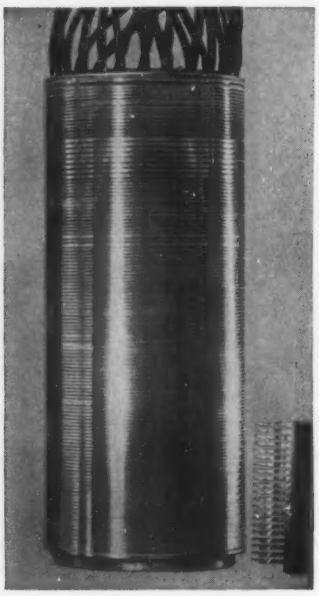
DEPT. 285A1, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in principal cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

See Reliance in Booth 2023, Design Engineering Show, New York Coliseum, May 23-26.

underwood
CANOGA DIVISION
chooses
Superior
to build the
SLIP RING ASSEMBLY
for its Model 8400
Tri-Ped Triaxial Antenna

This Superior slip ring assembly is part of the world-wide Discoverer satellite command and tracking system . . . 130 coin silver rings and 260 Superior silver graphite brushes. Length — 29-9/32"; o.d. — 11-3/8"; i.d. — 9-3/8".



Underwood Corporation comments upon this notable development as follows:

"The Tri-Ped three axis antenna represents a high order of state-of-the-art accomplishment and 'Ingenuity Engineering'. The basic design objectives of simplicity, reliability, ease of maintenance and low weight have been fulfilled—and surpassed."

We at Superior have been happy to share in the perfecting of the Underwood-Canoga Tri-Ped Triaxial Antenna. The same exceptional acquaintance with the intricacies of designing and building slip ring assemblies is yours to command.

Superior CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

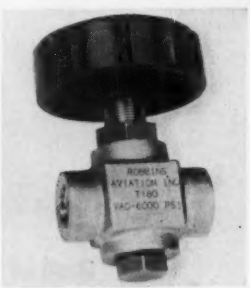
tinuous duty at 115 v, 60 cycles. Other choices include four frame sizes; round body, resilient or rigid mounting; two, four, and six-pole speeds, and capacitor-start induction-run, split-phase, permanent split-capacitor, or polyphase design. **Fractional Horsepower Motor Div., Robbins & Myers Inc.**, Springfield, Ohio.

Circle 632 on Page 19

Metering Valve

is three-in-one unit

Designated T-180, new 6000-psi metering valve configuration formerly required three types of valves. Valve can be used as a three-port unit with two ports in common, as a globe valve, or as an angle valve. O-ring seal plug closes off one of the three ports when unit is used as a globe or angle valve. Of all-stain-



less-steel construction, valve weighs 1.06 lb, has 3/16-in. diam flow passage, excellent metering characteristics, low operating torque, and an operating temperature range of −65 to +250 F. Unit can be panel mounted in 30 seconds. **Robbins Aviation Inc.**, 2350 E. 38th St., Los Angeles 58, Calif.

Circle 633 on Page 19

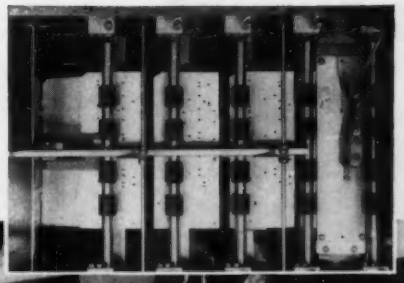
Threaded Fastener

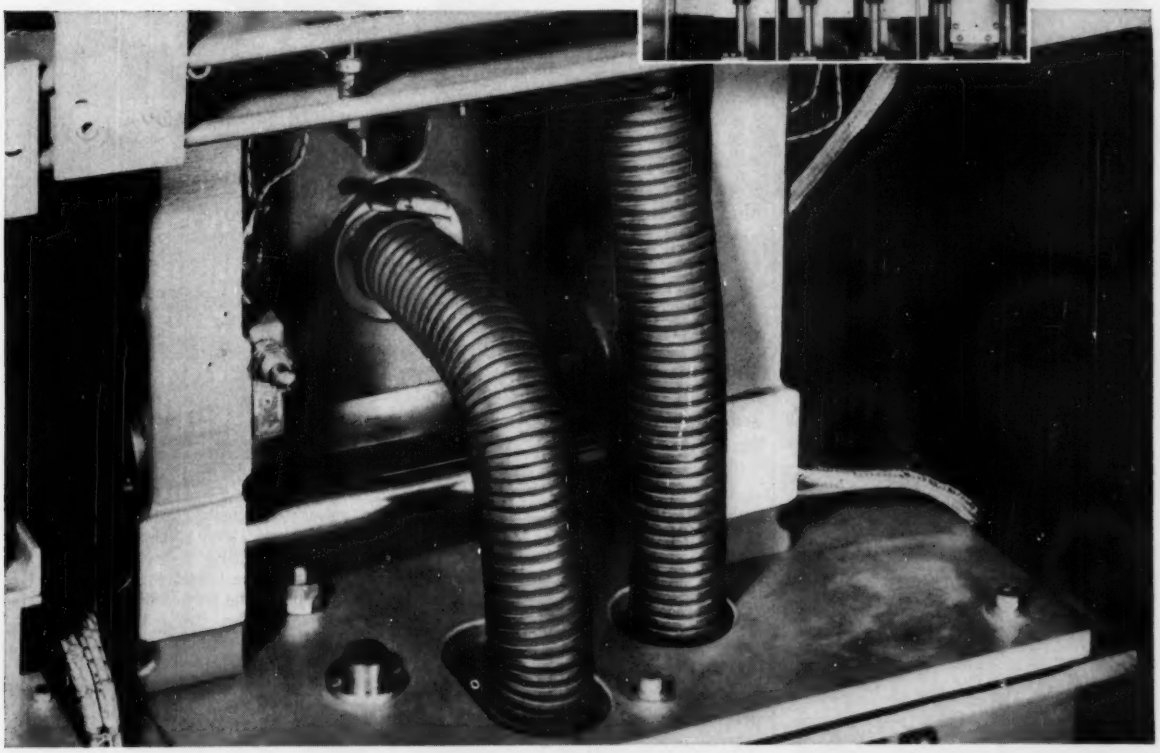
is lightweight, high-strength unit

Lightweight version of high-strength 900-F threaded fastener is available for aircraft, missile, and other elevated-temperature use. Actually two new products in one—an LWB 922 bolt and companion FN 922 nut—the fastener is 20 to 30 per cent lighter than original 900-F unit. Rated at 220,000 psi minimum tensile strength at room temperature, series is made lighter by reduction

Circle 486 on Page 19

This is one of the greatest card tricks you've ever seen





This is how Flexible Tubing helps Univac* designers bring it off

In the Remington Rand Univac, Solid-State Computer, the high-speed reader reads 450 punched cards *twice* every minute, and compares the two readings on every card.

Cards must be positioned exactly right in the feeder — and held there! Strong suction does the trick . . . strong suction provided through two lengths of Flexible Tubing Corporation's noncollapsing "Flexflyte." A third length gives the high speed reader a rugged, vibration-free connection between the suction turbine and the distribution manifold. The great flexibility and toughness of "Flexflyte" permits it to stand up under the constant movement of the picker knife.

Chances are you don't design high-speed computers. But if you work on any kind of original equipment where the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product that can do the job! You can choose fabrics, coatings, diameters and sizes to fit your specifications. Flexible Tubing is now being used on a wide range of original equipment — diesel engines, farm combines, industrial gluing machines, television transmitters, vacuum cleaners and many other products.

Univac is a registered trade-mark of the Sperry Rand Corporation

Flexible Tubing
CORPORATION
Guilford, Connecticut

Flexible Tubing Corporation, Guilford, Conn.

Gentlemen:

I'm designing a new product ☐ I'm redesigning an old one ☐ One of my problems is the handling of air ☐ liquids ☐ light solids ☐ Could be Flexible Tubing can help me solve them. I'll give you 10 minutes to show me, to prove it. Phone for appointment ☐ No problems right now. Send me literature for my files ☐

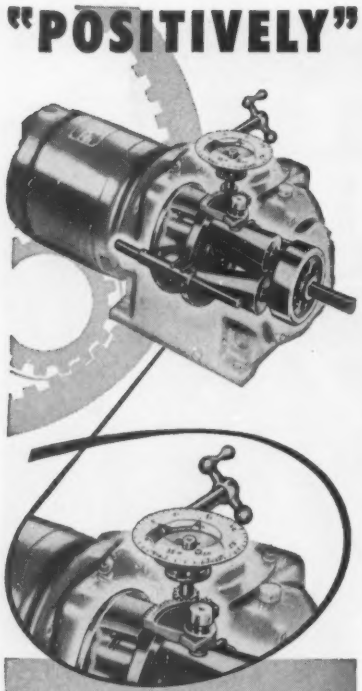
NAME .....

COMPANY .....

ADDRESS .....

CITY ..... STATE .....

"POSITIVELY"



Graham
THE MOST
ACCURATE*
Variable Speed
DRIVE

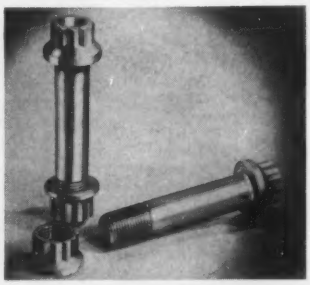
Now . . . get accuracy of speed set, reset and speed holding over full range — any desired maximum to zero — with the most *positive* of infinitely variable speed drives . . . the GRAHAM. . More *positive* than the induction motor that drives it, the GRAHAM gives unequalled speed regulation with change of load, plus built-in overload protection. The GRAHAM offers a wide choice of built-in motors, reducers and controls — pneumatic, electrical and a micrometer type with 4000 graduations for full range.

*Better regulation than other infinitely variable speed drives, including most closed loop types.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE OR WRITE FOR COPY

Graham
TRANSMISSIONS, INC.
Menomonee Falls, Wisconsin

Circle 488 on Page 19



in dimensions of 12-point external wrenching nut and bolt head. Combination is intended for use with harder aircraft and missile structural materials, such as high-strength aluminum alloys, stainless steels, and superalloys. Bolts and locknuts are available in all standard sizes from No. 10 through 1½-in. diam with fine threads. **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 634 on Page 19

High-Impact Resins

have improved toughness characteristics

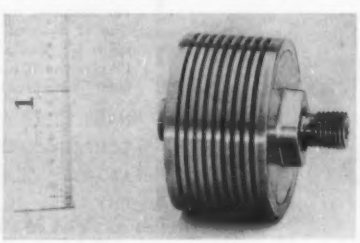
Added to high-impact series of polystyrene resins are Styron 475B and 475C, which have excellent impact properties at both room and low temperatures. Styron 475B is an extrusion resin, recommended for thermoforming operations where plastic is first extruded into sheet and then formed by heat and pressure. Styron 475C is a molding resin, an easy-flow, high-impact material designed for use in most molding applications. especially in thin-section parts or those where long flow areas are encountered. **Dow Chemical Co.**, Midland, Mich.

Circle 635 on Page 19

Sensory Bellows

for use with cryogenics

Lightweight sensory bellows for airborne applications is fully ma-



"the HITCHINER way..."

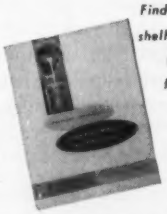
saves 35 MACHINING OPERATIONS with INVESTMENT CASTING

This barrel of a .22 caliber target revolver is now being cast by Hitchiner's new ceramic shell process. This new investment casting technique provides sufficient close tolerances and finishes to eliminate the need for 35 machining operations. Gun barrel tolerance of 0.006 inch was normal, but plus over minus 0.001 inch was maintained on certain areas. Only external finishing needed was partial polishing.

These savings have allowed the manufacturer of this revolver to sell it for considerably less than a similar previous model.

Through investment casting, parts can be designed for function and maximum operating efficiency with the widest selection of alloys from which to choose. This freedom from manufacturing problems can result in more flexibility in design and less waste in production.

Send us a sample or blueprint and check your specific problem with our "engineered quotation" — no obligation, of course.



Find out how our new ceramic shell technique can possibly benefit you. Send for our free, new revised brochure explaining investment castings.

HITCHINER
MANUFACTURING COMPANY INC.
MILFORD 37, NEW HAMPSHIRE

Coast to Coast Engineering Representatives

Circle 489 on Page 19

Setko's 23 Years of Progressive Engineering Experience Keeps Screws Modern as Tomorrow's Products

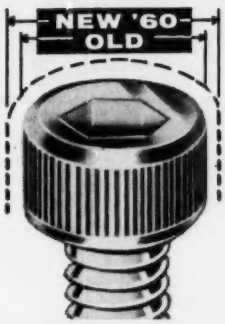
SETKO NEWS

We Specialize in Solving Puzzling Screw Problems

Bartlett, Illinois (Chicago Suburb) Progress Edition

NEW '60* SERIES CAP SCREWS HAVE EXTRA HOLDING POWER

4 BIG EXTRA MONEY-SAVING ADVANTAGES WITH SETKO



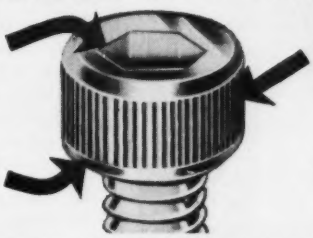
Compare the new head sizes of the new '60 series with the old '36 series and you'll *see* the many *extra* money saving advantages you get. For example: *Broader bearing area under the head*—often eliminates the need for washers. *Bigger head sockets for greater tightening torque*—give more holding power.

You get this extra size only where it counts—in the extra width of the head. (Head height remains unchanged.) In addition, you get *longer service life* and *more re-use value* when you specify Setko '60 series, Cold-Forged, Socket Head, Cap Screws.

LARGER HEAD SIZE PAYS OFF IN SAVINGS

BIGGER HEAD SOCKETS on many sizes take greater tightening torque without breakage or damage.

BROADER BEARING AREA under the head, distributes the load over a larger bearing area. Stops needless indenting of softer metals.



BETTER STRENGTH CHARACTERISTICS assure longer life—can be reapplied more times.

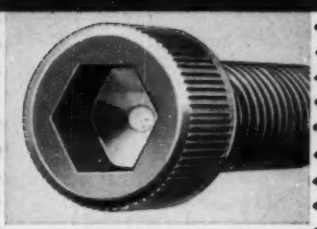
STAINLESS STEEL Cold-forged Cap Screws now available in many sizes.

DATA CHART SHOWS INCREASED SIZES

*'36 series will continue to be available.

Screw Size	Min. Head Dia. Inches		Bearing Area Min. Sq. In.		% Increase Bearing Area	Hex Key Size (Width Across Flats)	
	1936	1960	1936	1960	1960 over 1936	1936	1960
# 2	.136	.134	.006	.006	—	1/16	5/64
# 3	.157	.154	.008	.008	—	5/64	5/64
# 4	.178	.176	.011	.011	—	5/64	3/32
# 5	.200	.198	.015	.015	—	3/32	3/32
# 6	.221	.218	.019	.019	—	3/32	7/64
# 8	.265	.262	.026	.026	—	1/8	9/64
#10	.306	.303	.036	.036	—	5/32	5/32
1/4	.367	.365	.044	.044	—	5/32	5/32
5/16	.429	.457	.052	.070	33	7/32	1/4
3/8	.553	.550	.111	.111	—	5/16	5/16
7/16	.615	.642	.147	.200	36	5/16	3/8
1/2	.739	.735	.183	.183	—	3/8	3/8
5/8	.863	.921	.216	.293	35	1/2	1/2
3/4	.987	1.107	.224	.424	89	5/8	5/8
7/8	1.111	1.293	.253	.585	131	3/4	3/4
1	1.297	1.479	.405	.768	89	3/4	3/4

For dimensions on 36 series see latest Setko Catalog.



A Setko exclusive

"PERFECT-HOLE" SOCKETS

assure perfect key engagement!

You can exert maximum torque for *total* holding power because the hex socket is perfect. Permits perfect engagement of hex key against all of the bearing walls of the socket. Pressures exerted on the socket, are perfectly equalized for maximum driving power. Cap Screw life is extended and more re-applications are possible. Specially designed machinery and die tools, built to Setko specifications, are the reason for these cost-cutting, life-lengthening, money-saving, *plus* features.

Ask for free test samples

NEW FOLDER GIVES ALL THE FACTS

Contains complete specifications, dimensions and information about the new Setko '60 series of Cold-Forged, Socket-Head, Cap Screws. Fill in the coupon below, tear out and mail today. Ask for free test samples. Send us your requirements for advantageous quotations.

SETKO

Set Screw & Mfg. Co.
28 Main Street
Bartlett, Illinois

- ☐ Send me new free folder on Setko '60 Series Socket Head Cap Screws.
- ☐ Send me test samples of size .....'60 Series Cap Screws.
- ☐ Requirements attached, please send me your advantageous quotations.

Please write your name, company and address on the margin of this page.

(Advertisement)

No. 13 of a series

DETAIL OF ERECTOR PARALLAX TUBE
WITHIN THE REDFIELD BEAR CUB SCOPE
Windage knob
A neoprene ring bonded to the inner and outer tube

Eastman 910 Adhesive solves another production bottleneck

Ames Rubber Company, of Hamburg, New Jersey, assembles the erector parallax tube for the Redfield Gunsight Company's "Bear Cub Scope," a precision telescopic rifle sight.

In it, two concentric aluminum tubes are bonded to a neoprene ring.

Vulcanizing the ring in place required complex jigs, long curing times. Labor and material costs were high. Concentricity tolerances were frequently exceeded, with a resulting high rejection rate.

Fast-setting, high-strength Eastman 910 Adhesive solved their problem. *Now the part is assembled in 2 minutes, goes to the shipping room within 5 minutes.*

Over 50,000 units have been produced with no reports of bond failure.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. When spread into a thin film between two surfaces, light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9105 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-5, Kingsport, Tenn. (Not for drug use)

Circle 491 on Page 19

chined, and designed for a maximum pressure differential of 100 psi and temperature range of −450 to +1000 F. Principal application to date has been in LOX pressure regulation, although unit is suitable for other applications. Bellows units are available in aluminum, stainless steel, nickel alloys, and other materials. Hysteresis is almost zero due to machined bellows design. Bellows design has also withstood, under test conditions, over 10 million cycles without metal failure. Units are available in an infinite range of diameters and strokes. **Hydrodyne Corp.**, 7350 Coldwater Canyon, North Hollywood, Calif.

Circle 636 on Page 19

Miniature Switch-Light

has either neon or incandescent plug-in lamp

No. 6DR push-to-test Switchlite is a nonsnap, normally open, momentary-contact type rated at ½ amp, 115 v ac. It is designed for either neon or incandescent replaceable lens and lamp. Lamp leads and switch terminals are brought out separately in a four-pin base socket, allowing versatility in use of switch and light, either independently or in combination with each other. Variety of plug-in neon or incandescent lamps, with numerous lens colors, can be provided. **Eldema Corp.**, 1805 Belcroft Ave., El Monte, Calif.

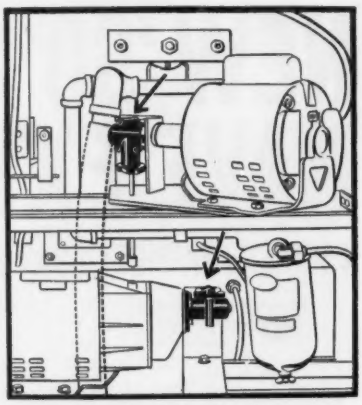
Circle 637 on Page 19

Solid Tantalum Capacitors

for continuous operation in −80 to +125 C temperatures

Aerotan capacitors are solid tantalum electrolyte units, featuring sintered tantalum anodes, hermetical-

ANGLgear® simplifies another 90° drive problem



Drawing based on photograph of Unicorn film cleaner shows location of Model R-330-2 ANGLgear units used respectively to transmit power to cleaning rollers and drive rollers.

In designing an automatic cleaner for motion picture film and magnetic tape, Unicorn Division of Computer Measurements Co., Sylmar, Calif., selected ANGLgear instead of open bevel gear drives for the following reasons:

(1) Lower initial cost and faster assembly — because ANGLgear eliminates design and installation of individual shafts, gears and bearings; (2) greater compactness—helps cut bulk; (3) more rigid drive—no possibility of gears getting out of mesh; (4) quieter operation.

If you have a design requirement for 90° power takeoff, investigate ANGLgear, the standardized right-angle drive. Completely enclosed, permanently lubricated, and featuring universal mounting, it is easily incorporated in your power transmission systems and requires virtually no maintenance.

You can specify ANGLgear from stock in ½, 1, 2¼ and 5 hp ratings, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting. See Sweet's Product DesignFile or contact our local distributor.

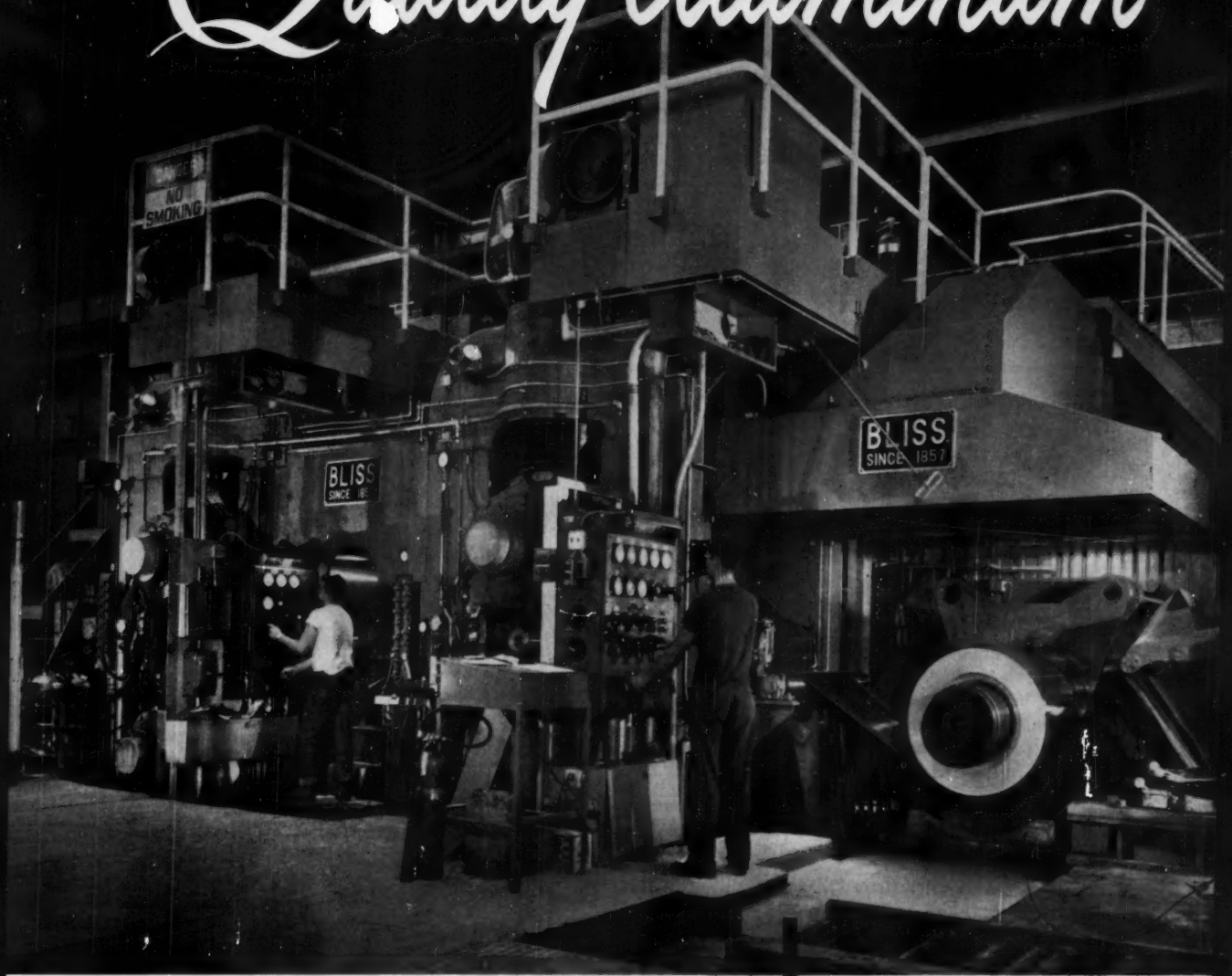
AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 492 on Page 19

MODERN EQUIPMENT PRODUCES *Quality Aluminum*



THE quality story of the new Bliss 4-high tandem cold mills is one of extra power . . . power that permits skilled operators closer gauge controls. It insures better sheet shape. Smaller work rolls allow frequent roll changes—assure better surface conditions on all finished sheet and coil.

Working with the latest and best equipment in the industry, QSM's metal specialists produce aluminum of the finest quality. Want proof? Ask anyone on our list of customers!

QUAKER STATE METALS CO. • LANCASTER, PA.

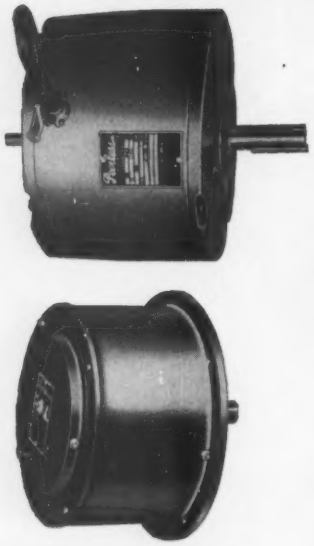
Division of HOWE SOUND COMPANY

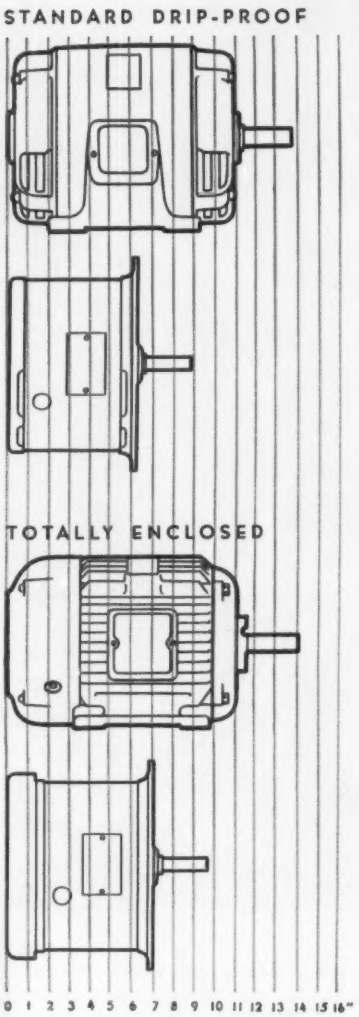
Mill Producers of Aluminum Sheet and Coil

Circle 493 on Page 19

For More Motor in Less Space

...WRITE PEERLESS ELECTRIC





PEERLESS ELECTRIC SPACE-SAVER MOTORS

If this is your problem, this Peerless Electric Space-Saver may be the answer. The line includes both drip-proof and totally enclosed designs in ratings from ½ to 10 HP. Bearings are prelubricated, double-shielded type. Peerless Electric will work with you to meet such special requirements as torque, mounting, enclosure, duty or insulation.

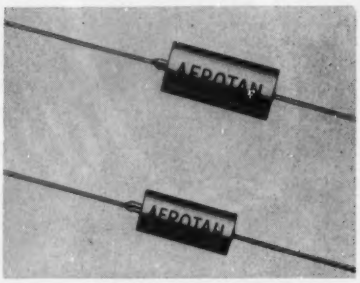
Peerless is a specialist in OEM applications—finding or designing the *one* motor which will power your product best. Talk with a nearby Peerless Sales Engineer or write direct. And for complete data on Space-Saver Motors, ask for Bulletin SP-1 from *Peerless Electric Division, H. K. Porter Company, Inc., W. Market Street, Warren, Ohio.*

PEERLESS ELECTRIC DIVISION

PORTER

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products asbestos textiles high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.



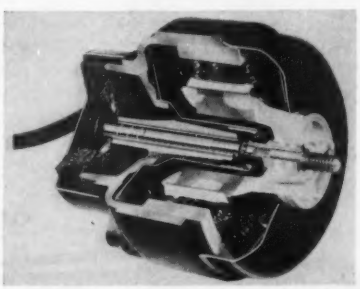
ly sealed in subminiature metal cases. Use of semiconductor electrolyte insures a completely dry assembly with freedom from corrosion or electrolyte leakage. Capacitors are available in Type ST-12, uninsulated case, and Type ST-13, insulated case, for continuous operation over temperature range −80 to +125 C in voltage ratings of 6, 10, 15, 20, and 35 v dc for +85 C operation, and 4, 7, 10, 13, and 23 v dc for +125 C operation. **Aerovox Corp.**, New Bedford, Mass.

Circle 638 on Page 19

Shaded-Pole Motor

is 51-frame, fan-type unit

Type KSP 3½-in. diam, 51-frame, unit-bearing shaded-pole motor operates as a condenser fan motor or evaporator fan motor on food and beverage coolers, vending machines, frozen-food and ice-cream display cases, domestic refrigerators and freezers, walk-in coolers, and condensing units. It can also be used to drive air-moving devices on forced-draft space and room heaters, fans and blowers, and kitchen ventilators. Lubrication system contains three times the supply of oil as compared to former models. Variations in recirculating lubrication system of horizontally mounted motors permit correct lubrication for vertical shaft-up and all-angle



mounting requirements. Bearing material with a new finish and high load-carrying capacities is utilized in the motor. Shaft rides on hydrodynamic oil film which helps reduce bearing wear and noise. Stator and bearing housings are one-piece, cast-iron construction. Motors are single-phase, rated 1.5 to 16 w, 115 and 230 v, 60/50 cycles. **General Electric Co.**, Schenectady 5, N. Y.

Circle 639 on Page 19

Venturi-Type Valve

for air, gases, fuels is only 5½ in. high

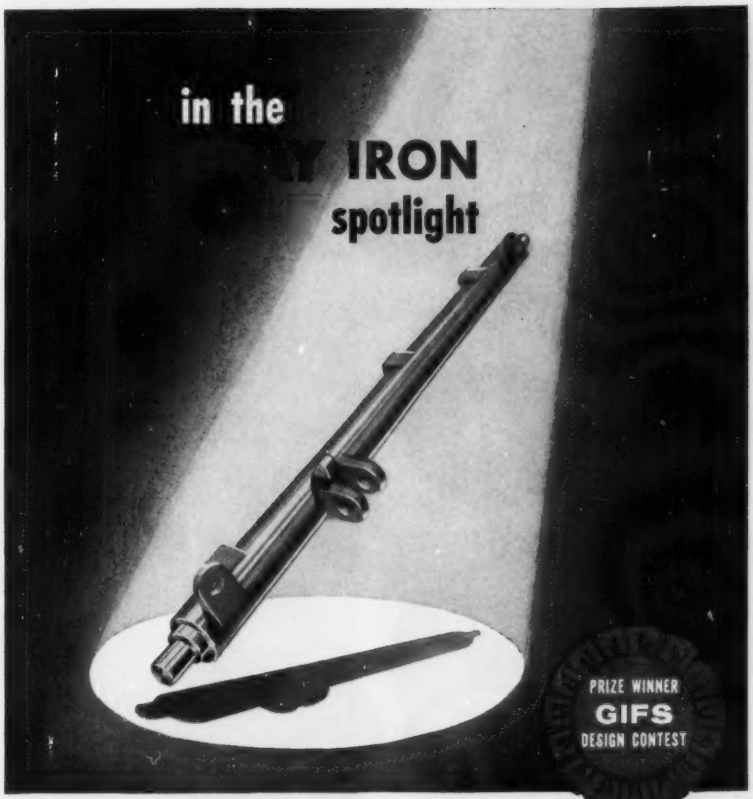
Direct-acting, venturi-type valve, in a 1-in. line size, weighs only 1¾ lb and is 5½ in. high. Valve combines floating disc, efficient venturi, and direct-acting design to produce maximum reliability. High-temperature insulting materials are used: Teflon, silicone, and glass. Coils are unaffected by mechanical and thermal shock, and maintain dielectric strength under salt spray and temperatures to 500 F. Both valve and solenoid are rated from 0 to 255 psi, over ambient-temperature range of −65 to +250 F, with fluid temperatures between −30 and +350 F, and up to 550 F for 10 minute maximum. Valve is easily adaptable to any type of fitting. **Valcor Engineering Corp.**, Carnegie Avenue, Kenilworth, N. J.

Circle 640 on Page 19

Thermal Timer

has settings up to 2 min

Low cost, completely housed thermal timer, Model 261, has two terminals for the heater circuit. It is available with normally open con-



How $18,000 was saved by redesigning complex assembly into single iron casting

Integral gray iron castings are a logical consideration for complex parts. An outstanding example of the savings that result when the cast iron process is used to place metal exactly where needed is this camshaft for a Teletype Printer. Formerly constructed of 31 parts laboriously machined and screwed together, an informed gray iron foundryman helped design engineers convert the assembly into a single high strength iron casting. An estimated $18,000 per year was saved in parts cost alone. Consider the gray iron process *first* in the design of complex parts. You, too, will achieve important material, weight, machining and assembly savings!

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

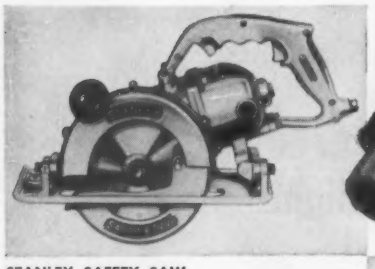
Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern

GRAY IRON CASTINGS

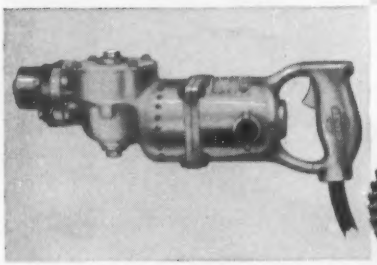
Made by Informed Foundrymen!

Circle 495 on Page 19



STANLEY SAFETY SAW

STANLEY UNISHEAR



STANLEY HAMMER

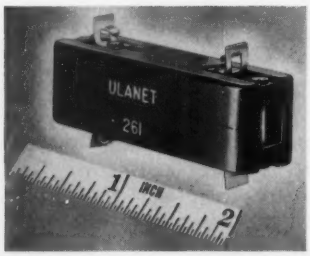
trouble-free, custom-cut precision gears for STANLEY

STANLEY ELECTRIC TOOLS, manufacturer of power tools, is famous for quality and dependability. They demand trouble-free gear performance.

Cutting precision gears of all types and sizes to customers' specifications is our business. As part of this, Perkins custom-gear engineers work closely with our customers' designers and production staffs. We can help you too . . . in design, improved performance, and cost control. "It makes good sense to use the help of gear experts with 52 years experience." What are your gear problems?

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

PERKINS
MACHINE AND GEAR CO.
Dept. 93 West Springfield, Mass.
Telephone: REpublic 7-4751



tacts which close after energization, or normally closed contacts which open after energization of the heater. Timer settings are available up to 2 min. Contact rating is 100 w, 115 v ac noninductive load, and stock heater winding is rated at 24 v. **George Ulanet Co.**, 413 Market St., Newark 5, N. J.

Circle 641 on Page 19

One-Tape Fastener

has back-to-back hook and loop sides

Back-to-Back Velcro consists of a single strip of nylon tape faced on one side with tiny hooks and on the other with soft loops. Formerly available only as two strips of tape, one the hook and the other the loop portion, new one-piece tape can be fastened together upon itself. It is more supple and pliant than the twin-tape fastener, and has shear strength of 6-8 psi. It is suitable for wires that have to be held together in separate groups, as wells as for

temporary ties in which repeated accessibility or replaceability is required. Material has excellent insulating properties. It is available in ½ or 1-in. widths and in 14 standard colors. **Velcro Corp.**, 681 Fifth Ave., New York 22, N. Y.

Circle 642 on Page 19

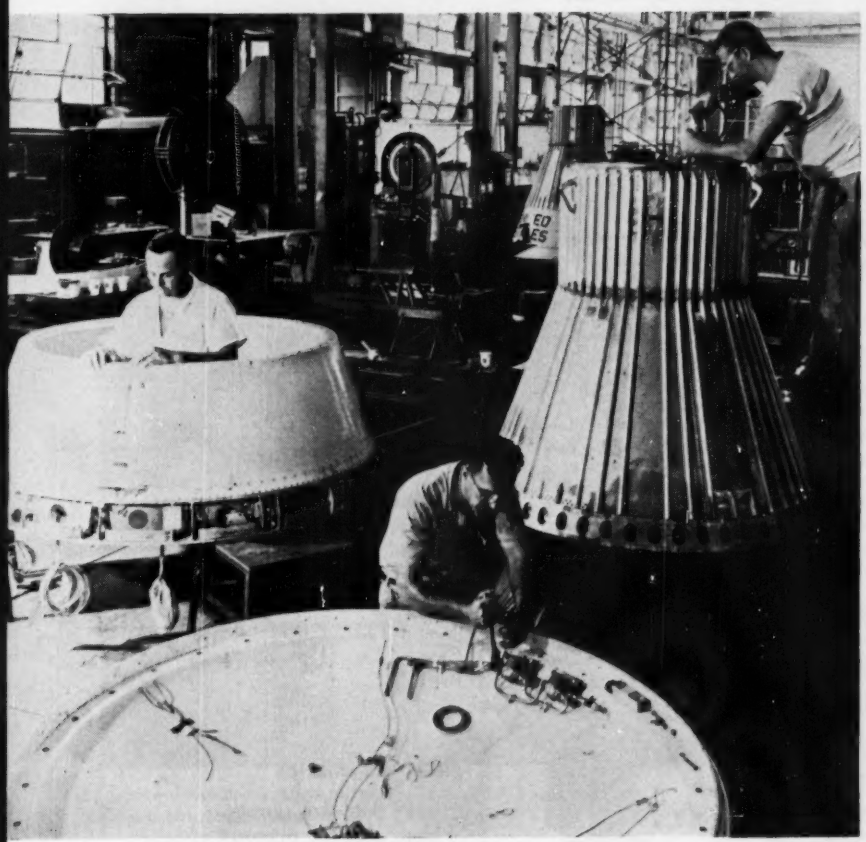
Synchronous Motor

for stepping or 72 rpm constant speed

Slo-Syn synchronous motor, Type SS50, is a permanent-magnet ac

Circle 496 on Page 19

Product-Design
BRIEFS
from Durez



MORE ABOUT UNCLE'S MONKEY

Uncle Sam's first astronaut was a rhesus monkey, also named Sam, who took a 55-mile-high ride in a vehicle called Little Joe. It is Little Joe we're concerned with.

Specifically, with the part of Little Joe made from heat-resistant Hetron® polyester resin.

The full-scale Little Joe capsule is 9½ feet tall, 20 inches across the top and 6 feet across the rounded base. The bottom portion of this capsule consists of a heat-absorbing shield of glass-reinforced Hetron. Its several layers add up to an inch of thickness.

Hetron was chosen after intensive research because it provides an unusually high degree of inherent heat resistance, heat stability and fire resistance. All of these properties are important in coping with heat generated by atmospheric friction at escape velocity. Ease of fabrication was pretty important, too.

The large photo shows the two Hetron portions of the capsule: the bottom, in foreground; the heat-shield, at left.

Not only Uncle Sam's sophisticated scientists, but also the more prosaic industrial designers are interested in Hetron. It offers great promise in many different applications.

For example, it makes possible small boats that are fire-retardant. Because it is highly resistant to many acids, it finds wide use in scrubbers, ductwork and similar places where corrosive fumes quickly destroy other materials. It's being used for skylights on piers. One company even enclosed an entire building with it.

Hetron can by no means be considered a cheap substitute for other materials. Designers have been impressed with it and have used it simply because it performs its function better than any other material they might have used. Sometimes it costs less than other materials. Sometimes it costs more. But, in either case, it does things better, longer or more safely than anything else. We've got a data file on it if you're interested. Ask for Hetron File A.

A THOUGHT FOR USERS OF DIE CASTINGS

When you put these seven parts together, you get a highly efficient low-cost pump for emptying drums of gasoline, lube oil or chemicals.

The manufacturer used to die cast these parts. Now he has them molded from a Durez phenolic. The switch to molding from die casting eliminated many finishing and assembly operations. Even the fine threads on one of the parts were flawlessly molded.

The switch to phenolic from aluminum added greater corrosion and chemical resistance. Being non-metallic, phenolics also prevent sparking and minimize the risk of handling volatile liquids.

For more facts about molding with versatile Durez materials, ask for Bulletin D400.

For more information on Durez products mentioned above, check here:

- ☐ Hetron polyester resins (File A)
- ☐ Phenolic molding compounds (illustrated Bulletin D400)

Check, clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

505 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 497 on Page 19

50,000 HOURS

of silent, synchronous power assembled in every *

HANSEN SYNCHRON® TIMING MOTOR

Manufacture of long-life, Hansen SYNCHRON Timing Motors is quality-controlled throughout, to make them the *best* synchronous motors for industrial and commercial applications. Skilled, experienced workers assemble Hansen SYNCHRON motors to rigid standards. Each motor undergoes 51 separate tests and inspections before shipment, insuring users of the ultimate in silent, continuous, synchronous power for specific timing applications.

Operating efficiently in any position, self-starting, self-lubricating Hansen SYNCHRON Timing Motors deliver from 8 to 30 in./oz. guaranteed torque; at temperatures from —40 F to +140 F; in speeds from 600 rpm down to ½ rph; clockwise or counterclockwise rotation. Over 200 types of output available.

The efforts of Hansen engineers have been concentrated in just one area for over 50 years — creating and applying synchronous power units to timing applications. Use this experience to solve your specific timing problems. Contact your nearest Hansen representative, or write direct.

HANSEN REPRESENTATIVES:

THE FROMM COMPANY
5150 W. Madison, Chicago, Illinois

H. C. JOHNSON AGENCIES, INC.
Rochester, N. Y. • Buffalo, N. Y.
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Schenectady, N. Y.

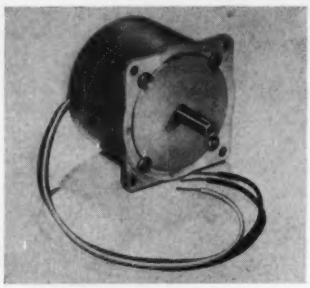
ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. (OLive 1-3220)
Oakland, Calif.

WINSLOW ELECTRIC CO.
New York, N. Y. • Chester, Conn.
Philadelphia, Penn. • Cleveland, Ohio

*An average figure for Hansen SYNCHRON Motors . . . many are designed for shorter life — others for years longer.

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

motor suited for a wide range of applications requiring 72 rpm constant synchronous speed and/or dc stepping with instant starting, stopping, or reversing. Ratings are: Input 120 v, 40/70 cycles, single phase, 0.30 amp maximum current at 60 cycles; 72 rpm output speed at 60 cycles, 50 oz-in. torque. Motor uses Class B insulation and is rated for 75 C temperature rise from 40



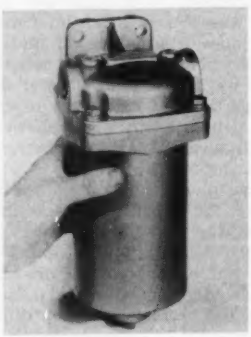
C maximum ambient under continuous duty. Standard types are available with planetary-gear speed-reduction assemblies providing speeds of approximately 16.6, 3.3, 0.67, 0.133, or 0.027 rpm. **Superior Electric Co.**, Dept. SS, 83 Laurel St., Bristol, Conn.

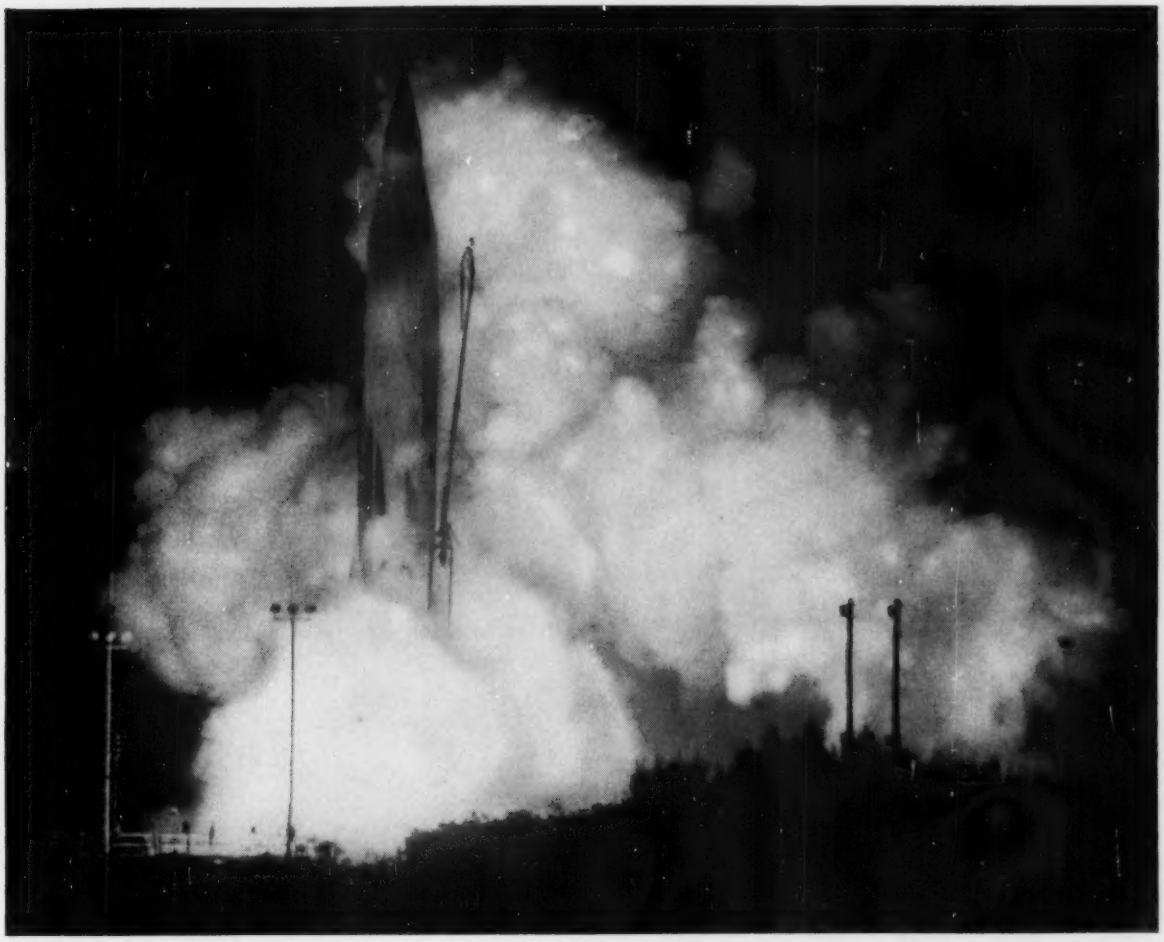
Circle 643 on Page 19

Filter Assemblies

have pore-size ratings from 2 to 100 microns

Line of general-purpose filter assemblies, Series 3100, is for use in the filtration of most fuels, lubrication oils, hydraulic fluids, air and other gases, and liquids. Assemblies have pore-size ratings from 2 to 100 microns and are available with five element materials: Woven wire cloth; sintered bronze; pleated, resin-impregnated cellulose washers; helically wound, resin-impregnated cellulose ribbons.





Record breaking Atlas missile billows flame and vapor as she launches 4¼-ton satellite into orbit. Constructed of Type 301 Nickel Stainless Steel, Atlas is built by Convair (Astronautics) Division of General Dynamics Corporation. *U.S. Air Force photo*

130 tons of missile with a skin thinner than a window pane!

The Nickel Stainless Steel skin of the Atlas missile is actually about one-third as thick as the glass in your window.

And yet look what this skin does:

- It is the sole structural framework for Atlas—130 tons of dead weight at the moment of firing.
- It serves as the wall of the propellant tanks in Atlas' weight-saving design.
- It withstands the deep chill of liquid oxygen (−297°F) . . . the high heat of supersonic speed (400°F–600°F).

. . . And it is less than 1/25 of an inch thick!

No wonder they call stainless the space age metal. No wonder engineers turn more and more to Nickel Stainless Steel as temperatures rise . . . as speeds soar . . . as demands get more and more severe.

But Nickel Stainless Steel has many earthbound applications, too. Its strength and resistance to both corrosion and temperature extremes improves the performance and prolongs the life of many industrial products. And its attractive appearance provides still another reason for its popularity in products for the home.

What's your metal problem? Is it high or low temperatures? Corrosion, stress, fatigue or an unusual combination of factors? Write to us about it. Perhaps Nickel—or one of its alloys—can help you get it off the ground.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

UNITCASTINGS provide answer for difficult parts problem!

Again, Unitcast Foundry Engineering proved invaluable in producing this hydraulic valve body casting.

Faced with the necessity of a durable, more compact unit, the customer investigated the advantages of *cast steel*. Firm specifications included small and irregular internal passages that were impossible to machine blind. Tolerances were close and exceptionally clean internal surfaces were a necessity. Shell cores, as illustrated, were used in a green sand mold. The system was streamlined and the more compact unit did not hamper the mechanism. Costs were reduced to a fraction of the alternate composite machined assembly.

Unitcastings can possibly meet your unusual problems, too. Why not investigate today . . . call for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

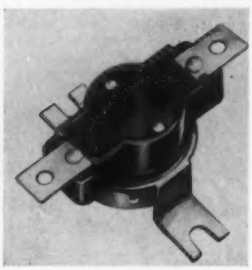
Over-all temperature range covered by the elements is −350 to +350 F. Flow rate and pressure-drop ratings are dependent on filter element materials and fluids to be filtered. Assemblies have a rated operating pressure of 150 psi with burst pressure of 600 psi. Housings are aluminum and are blue anodized. **Bendix Filter Div., Bendix Aviation Corp.,** 434 W. 12 Mile Rd., Madison Heights, Mich.

Circle 644 on Page 19

Snap-Acting Thermostat

has small size and flexible design

New ¾-in. disc-type thermostat, Series 206, is available for positive, snap-action temperature control in air-conditioning units, heating and ventilating equipment, dryers and combination washer-dryers, unit heaters, and countertop appliances. Unit provides reliable, high-capacity switching action at ratings to 25 amp, 240 v ac, resistive, and for accurate temperature repeatability over 100,000 operating cycles. Thermostat, with switch mechanism enclosed within a phenolic case, is available with fixed temperature settings to 350 F. Models operate either as limit switches or as fan switches. Both automatic-recycling and manual-resetting types are offered. **Metals and Controls Div., Texas Instruments Inc.,** 34 Forest St., Attleboro, Mass.

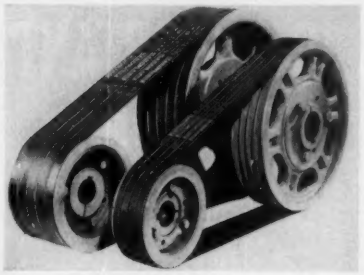


Circle 645 on Page 19

Compact Belt Drives

provide greater horsepower capacity with less bulk

Hi-Cap Wedge drives have sheaves and belts designed to provide greater horsepower capacity with less bulk than conventional V-drives. Drives supplement conventional drives and



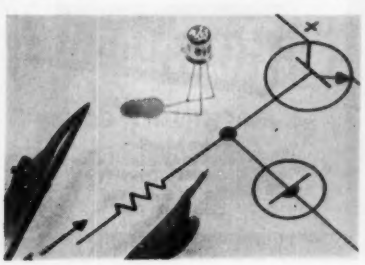
extend effective range of V-drive application. In installations above 25 hp, drives will generally provide a cost saving over most other drives. Between 10 and 25 hp, they compare favorably in cost to conventional V-drives. Sheaves utilize same QD bushings as used in conventional QD sheaves and QD roller-chain sprockets. Compared to conventional V-belts, Hi-Cap Wedge belts are narrower without sacrifice of area of sidewall contact with sheave groove. They make possible the transmission of horsepower by a more compact drive, with sheaves of smaller face width and diameter, and shorter center distances. **Fort Worth Steel & Machinery Co.**, 3600 McCart St., Ft. Worth, Tex.

Circle 646 on Page 19

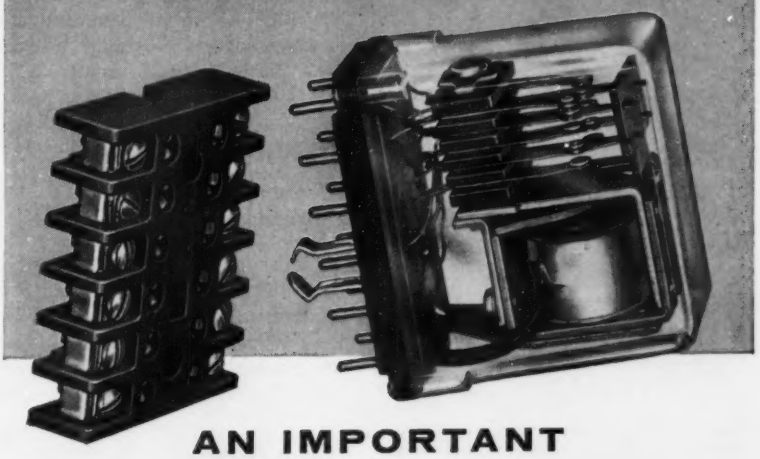
Germanium Tunnel Diodes

for use as circuit reference elements

Two germanium tunnel diodes, type numbers 1N2941 and 1N2969, switch at specific current levels and are ultrastable over their entire temperature range, allowing their use as reliable current reference elements. Computers and industrial and military control equipment are among the first applications. Peak-point current ratings of 2.2 and 4.7 ma conform to preferred value standard set by industry associations for electronic components. Both devices have typical peak-to-valley current ratios of 8:1. The 1N2941 has a



Dunco's answer to the problem of "over-relayed" industrial controls!



AN IMPORTANT

RELAY

for industrial control

219 Frame Relays, using heavy duty 12-pin plugs and sturdy industrial-type phenolic sockets, are Dunco's answer to the need for industrial control relays that are large enough, but not too large; fully dependable, but moderately priced. Designed for long, reliable contact life on relaying loads, they have proved outstandingly successful on laboratory-type "tail chasing" circuits and on machine control installations.

Dunco 219 Frame Relays have 10-ampere current carrying parts; 150-volt electrical spacings of ¼" over surface and ⅛" through air; and withstand 1500-volt die[illegible]c test. Three standard contact arrangements [illegible]ilable at *minimum* prices facilitate control circu[illegible] standardization and simplify field maintenance replacement problems.

Write Today for Dunco Engineering Bulletin 2219.

Member, National Assn. of Relay Manufacturers

STRUTHERS-DUNN

World's largest selection of relay types

STRUTHERS-DUNN, Inc., Pitman, N. J.

S-D

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Circle 501 on Page 19

SPECTROL PRECISION MECHANISMS

The Big Squeeze Job

SPECTROL'S new PRECISION MECHANISM—a velocity servo—is more than just another interesting shrink job. It's useful. It can go anywhere you need an ultra-miniature, precision speed control device.

First, the package. It measures only 1½ x 1½ x 3 inches. In a space that would give a sardine claustrophobia, Spectrol engineers squeezed a solid-state amplifier, a servo-motor, a gear train, and a very special, condensed (½-inch long) potentiometer and switch.

The pot has four electrically isolated wipers, all riding 90° apart on the same coil. The switch, in the same pot housing, has four wipers riding on an alternately conducting and non-conducting surface.

THE FUNCTION: The servo accepts dc signals varying between ±10 v from a computer to drive the pot in such a manner that speed is directly proportional to the dc signals.

THE APPLICATIONS: Here's an example: tied to an airborne computer, the Spectrol servo will drive a scope in the cockpit of one of the nation's hottest aircraft. The object: to give the pilot a visual, three-dimensional analog of his position. Actually, the servo will drive anything—resolvers, synchros, tachs, other pots and switches. It's a complete, ready-to-go package you can put into your system as is.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional subassemblies using components such as gear drives, clutches, precision potentiometers and servomotors. If you need modules combining any of these components in a *single specification*—Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 63.

18

SPECTROL

ELECTRONICS CORPORATION

1704 SOUTH DEL MAR AVE. • SAN GABRIEL, CALIF.

Circle 502 on Page 19

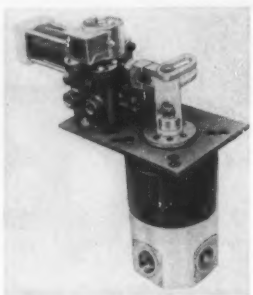
total capacity of 30 mmf while the 1N2969 is rated at a total capacity of 20 mmf. Diodes are rated for operation over an ambient temperature range of −55 to +100 C. They are housed in TO-18 standard transistor package. **Semiconductor Products Dept., General Electric Co.,** Charles Bldg., Liverpool, N. Y.

Circle 647 on Page 19

Cylinder-Operated Valves

for air, water, and hydraulic oil

Cylinder-operated Shear-Seal valves are rated for 10,000, 6000, and 3000 psi hydraulic oil or water, and 10,000, 4000, and 2000 psi air. They are available in four and three-way and shut-off flow patterns. Port



sizes range from ¼ through 1½ in. NPT. Operators are obtainable with cushioned or noncushioned cylinders for 80 to 250 psi air pressure and for 500 psi maximum oil or water pressure. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 648 on Page 19

Nickel-Silicon Bronze Alloy

has high tensile and yield strength

Nironze 635 is a nickel-silicon bronze alloy composed of 97.5 per cent copper, 1.9 per cent nickel, and 0.6 per cent silicon. In the ordinary hard-drawn state, alloy has equal ductility with 2 per cent silicon bronze and superior ductility to 3 per cent silicon bronze. By proper aging, it develops a higher tensile strength than 2 per cent silicon bronze. It has a greater yield than other silicon bronzes or mold steels, and is superior to aluminum alloys. Elongation and reduction of area values are very good. Applications

Engineers! Designers!

10 IMPORTANT REASONS

Why You'll like

Gusher

COOLANT PUMPS

SIMPLE, COMPACT DESIGN *with no metal-to-metal contact in the pump.*

ELECTRONICALLY AND DIAMETRICALLY BALANCED ROTATING ASSEMBLY, *increases bearing life—eliminates vibration.*

NO SEALS, NO PRIMING — *saves time.*

STREAMLINED APPEARANCE, *hand buffed finish.*

DELIVERS INSTANTANEOUS, COPIOUS COOLANT FLOW *the minute the machine is started.*

HEAVY-DUTY PRECISION BALL-BEARINGS *insure longer life.*

SHAFT IS ONE PIECE, *heavy duty construction, no couplings.*

PRE-LUBRICATED BALL BEARINGS *require no further attention.*

NO PACKING *or adjusting required.*

BALANCED THRUST *is obtained by using equalized pumping action.*

Model 11025

THE Ruthman

MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road
Cincinnati, Ohio

Circle 503 on Page 19

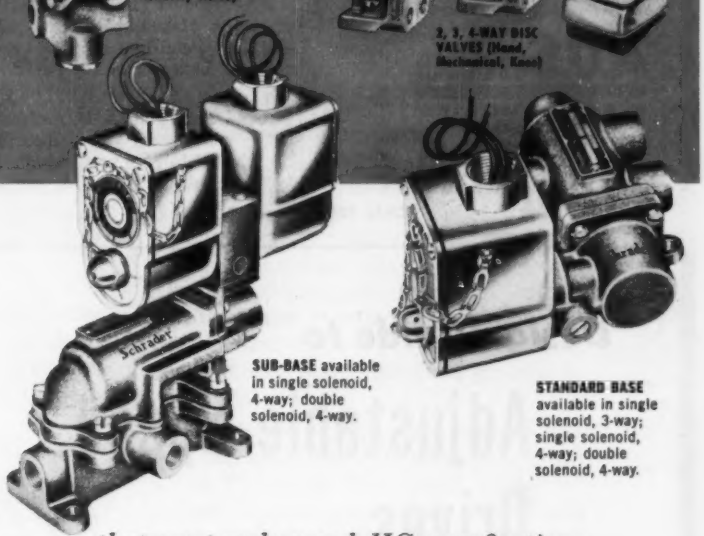
ALL THESE... *full lines from Schrader...*

2 and 2-WAY VALVES (Roller Lever)
2 and 3-WAY VALVES (Angle Lever)
2 and 3-WAY VALVES (Hand Lever)
2 and 3-WAY VALVES (Hand Lockdown)
3-WAY SINGLE SOLENOID VALVES
4-WAY DOUBLE OR SINGLE SOLENOID VALVES (Sub Base)
4-WAY VALVES (Hand, Lockdown)
4-WAY STANDARD OR SUB BASE VALVES (Pilot Operated)
4-WAY DOUBLE OR SINGLE SOLENOID VALVES (Standard)
DISC VALVES—PIPED EXHAUST TYPE (Hand, or Mechanical Operated)
4-WAY VALVES (Foot, Lockdown)
2 and 3-WAY PILOT VALVES (Timed or Fixed, Normally Open or Normally Closed)
2, 3, 4-WAY DISC VALVES (Hand, Mechanical, Knee)
4-WAY VALVES (Foot, Spring Return)
NEW DELAYED BLAST VALVE

AND NOW...

NEW JIC SOLENOID AIR VALVES

..... that meet and exceed JIC specifications



SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.

STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

Schrader's complete line of air valves allow you a freer hand in planning air circuits for your applications. Besides almost unlimited choice of size, style and actuation method, you get these extras in every Schrader valve you buy:

- All parts are designed for maximum air flow, longest service life; simplicity of replacement; interchangeability.
- Schrader Valves feature tough, practical design, precision construction, and are individually tested to full ratings.
- Performance has been proved by years of use in hundreds of plants. All Schrader Valves can operate with Schrader (JIC) Square End Cylinders perfectly.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

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QUALITY AIR CONTROL PRODUCTS

800 to 1 hp favorites for quiet operation, low maintenance and long-life service . . .

From the case of the A. O. Smith Motor Man — a complete stable of integrals that include single-phase models (1-5 hp) or polyphase (1-800 hp). Also a team of fractional-hp motors. All are sure bets to give top performance over the long, long haul.

And there's an A. O. Smith Motor Man near you — chomping at the bit to give you 24-hour action on all parts and service orders.

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Through research ...a better way

A.O.Smith
CORPORATION
ELECTRIC MOTORS
Tipp City, Ohio
A. O. SMITH INTERNATIONAL, S.A.
Milwaukee 1, Wisconsin, U.S.A.

Circle 506 on Page 19

Design Guide to

Adjustable-Speed Drives

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

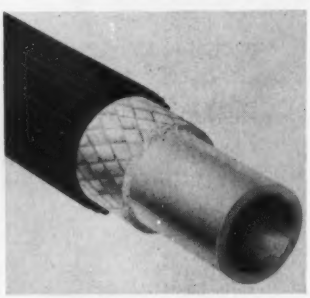
Penton Building
Cleveland 13, Ohio

include many in the electrical field where high strength, electrical conductivity, and corrosion resistance are important factors. Alloy is currently available in round rod and wire only. It ranges in length from 0.062 to 1½ in. and in coils from 0.062 to 0.625 in. **Bridgeport Brass Co.**, Bridgeport 2, Conn.

Circle 649 on Page 19

Pressure Hose

is lightweight, flexible, has high mechanical strength



Synflex pressure hose is available for all hydraulic and pneumatic applications. It consists of a precision-drawn inner-core tube of inert polyamide formulation over which is braided a tough synthetic covering to provide high burst resistance. A black plastic is extruded over the inner components to form a durable, abrasion-resistant outer sheath. Construction renders hose light in weight, flexible, and provides high mechanical strength, chemical and burst resistance. Hose can be used with all fluids normally encountered, including fuels and gasoline, grease and hot oils, butane and propane, antifreeze solutions, refrigerants such as Freon-12 and Freon-22, and Pydrol. Sunlight and moisture do not affect it. Hose is immediately available with core tube ID of 3/16 in. in 1/16-in. increments through ⅜ in. **Synflex Products Div., Samuel Moore & Co.**, Mantua, Ohio.

Circle 650 on Page 19

General-Purpose Relay

incorporates neon indicator lamp

Type KRP-N general-purpose relay is availabie for 6 to 110 v dc and 6 to 230 v ac operation. It incorpo-

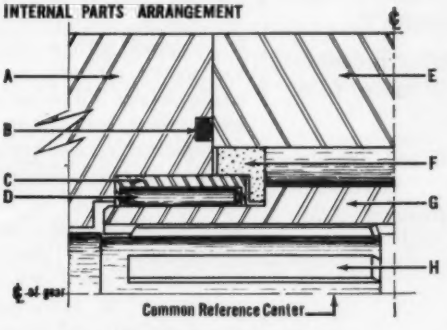
COMMERCIAL Announces...

A Remarkable New Fluid Power Pump

COMMERCIAL presents the new, Series 15H fluid power pump—a logical extension of its Series 36H line which has received such outstanding acceptance. This small powerhouse possesses all the proven basic features of the larger COMMERCIAL fixed displacement gear pump but is designed for those applications where flow requirements are less. The Series 15H is made in ½", ¾", 1", 1¼", 1½", 1¾" and 2" gear widths and covers a delivery range from 3 to 15 gpm at 1200 rpm. It is recommended for continuous duty operation at pressures up to 2000 psi—at speeds up to 2400 rpm. Volumetric and mechanical efficiency rate over 90%. 15H pumps are available for flange or pad mountings of many styles and can be furnished with ports to accept tapered thread, straight thread or SAE split flange fittings.

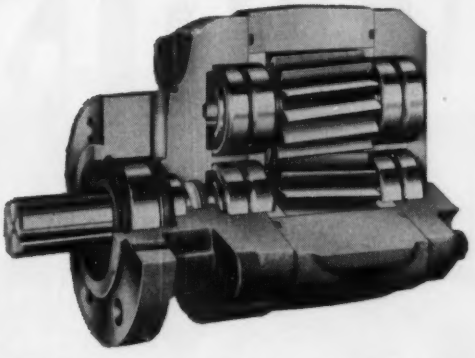
High performance for keeps

Perfect alignment is "built in" these pumps because of their unique basic construction which establishes the machining of all internal parts from one common reference, the gear center line. (See drawing.)



A-bearing carrier
B-"O" ring seal
C-bearing outer race
D-bearing roller
E-gear housing
F-floating thrust plate
G-gear
H-drive shaft spline

As shown, gear bearings also act as dowels—outmoded dowel pins are eliminated.

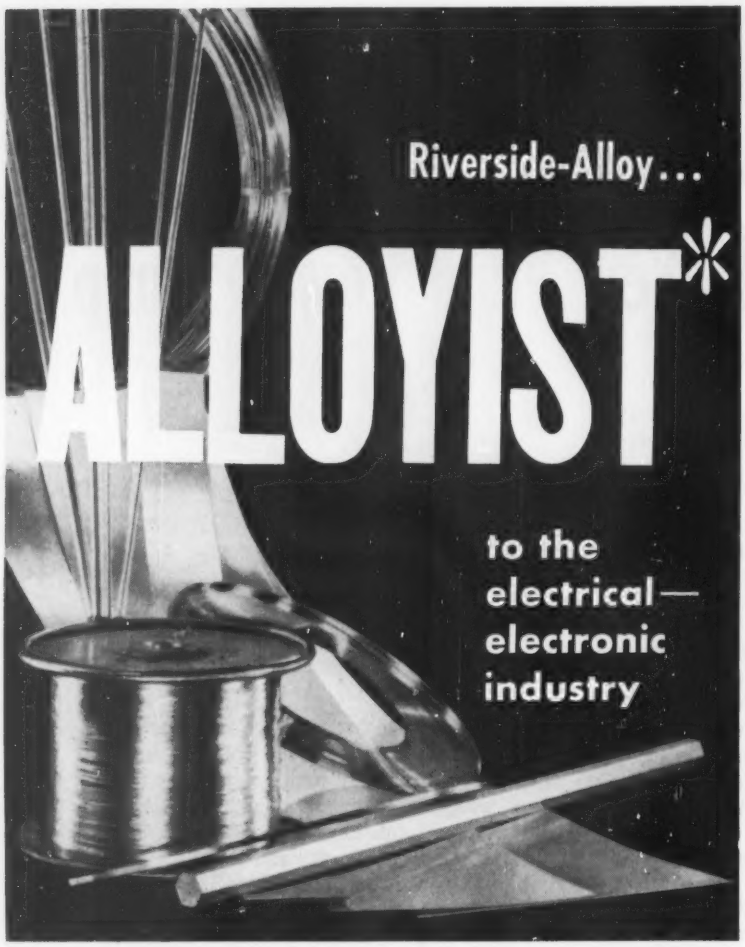


Matched helical gears having mirror finish ground on all surfaces contribute to high volumetric efficiency and quiet operation. Thus, complete sealing is maintained—tooth to tooth and tooth to gear housing. Ruggedness, greater load capacity and dampening of unbalanced internal loading are assured by using integral gear hubs to serve as journals for the pump's oversize gear bearings. In order to meet its own exacting standards, COMMERCIAL must, and does, produce its own gears.

A dynamic seal is maintained between gear faces and special bronze alloy gear thrust plates. The entire thrust plate "closes in" against the gear face because of pressure pocketed behind the plate, thus compensating for any wear on its gear contact surface. Because the sealing area is confined to a small portion of the contact surface, the amount of friction has no appreciable effect on pump mechanical efficiency.

Engineering experience available—personal technical service and assistance is yours for the asking. For more information write to Commercial Shearing & Stamping Company, Dept. S-22, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping



*ALLOYIST—Our own almost-Websterial word, meaning: a single reliable source for strip, rod, wire and flat wire to serve your every need.

*ALLOYIST—A single, reliable source for nickel, nickel silver, cupro nickel, stainless steel, phosphor bronze, Monel** and Inconel**.

*ALLOYIST—A supplier of metals whose manufacturing processes are often exclusive, and *always* the most advanced, to insure total product superiority.

Put the *Alloyist* on your Design Staff, Purchasing Staff and Production Staff. We know of only one fully qualified Alloyist . . . Riverside-Alloy Metal. Write today for complete information. *Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N.J.*

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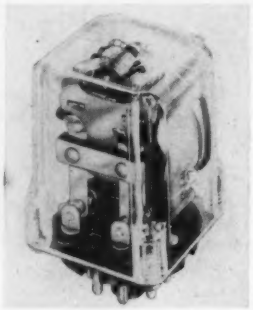
Visit Booth #148 at the Southwestern Metal Exposition
Visit Booth #142 at the Design Engineering Show

RIVERSIDE-ALLOY PORTER **METAL DIVISION**

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.



rates a neon indicator lamp connected in series with a resistor. Both components are connected in parallel to the relay coil to provide a positive means of determining current availability. Transparent cellulose-acetate dust cover provides operating visibility for lamp and contacts. Silver cadmium contacts rated at 10 amp are standard for both ac and dc models, and silver contacts are rated at 5 amp. Contact arrangements are available up to three pole, double throw. Relay is 2 in. high and 1 13/32 in. square. **American Machine & Foundry Co., Potter & Brumfield Div.**, Princeton, Ind.

Circle 651 on Page 19

Vibration Inducer

weighs only 4½ oz

Lightweight BD-10 redesigned vibration inducer now weighs only 4½ oz yet retains power and strength of 11-oz predecessor. Unit is equipped with a replaceable jet for greater air economy than preceding model. Vibration is generated by a rolling ball driven in an orbit on replaceable raceways of hardened high-alloy steel, precision ground. Operation is safe in explosive atmospheres. Special lug allows mounting in any position with a single bolt. Used to bring powdered, particulate or granular materials out of hoppers and down chutes, vibrator handles bins with 4-cu ft

Maxitorq
9000 SERIES*

ELECTRIC CLUTCHES or BRAKES

Featuring these
Advantages:

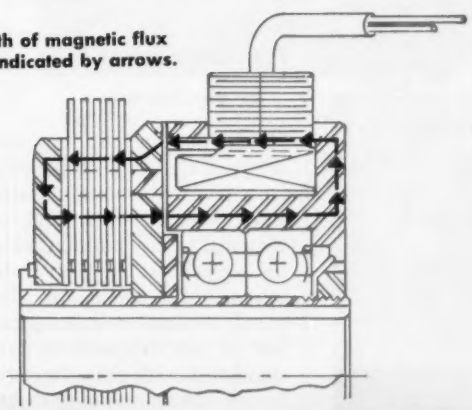
- **Compact and Simple Design**
- **Built to American Standards**
- **Stationary Coil**
- **No Slip Rings or Brushes**
- **Self-Adjusting—Easily Installed**
- **Drag-free Floating Neutral**
- **No Stressed Levers or Parts**
- **Use as Brake or Clutch**
- **Standard Flange Cups Available**

*Patent applied for.

OPERATION INDUCED ENTIRELY BY *Magnetic Flux*

The new Maxitorq #9000 Series Electric Clutch is a compact, self-contained unit with operation dependent upon induced magnetic flux. As shown in the drawing below, this new Maxitorq Clutch consists essentially of a sealed magnetic coil and housing arrangement actuating multiple discs which also act as the flux path. Because the coil housing, supported on anti-friction bearings, is stationary, troublesome brush and slip ring construction is eliminated. When energized, the entire assembly consisting of pressure plate, inner and outer discs, and buttress plate is locked together by the magnetic force passing through it. When de-energized, Maxitorq separator springs instantly separate the discs creating air gaps which help to break up residual magnetism. Compactness, fast response, and flexibility of control make the #9000 Series clutch or brake ideally suited for a wide range of applications.

Path of magnetic flux is indicated by arrows.



Write, phone, or wire Dept. MD now for Bulletin 90 describing the most advanced design of electric clutches or brakes available today.

THE CARLYLE JOHNSON MACHINE CO. • MANCHESTER, CONN.

Circle 509 on Page 19

is this design step really necessary?

Your problem power transmission component may already have been engineered by Charles Bond Company! Power transmission users the country over find it saves time and money to check with Bond first.

Time and again a review of the facts reveals that proven Bond *stock* components solve the problem without resorting to a new engineering approach, expensive dies and costly delay.

Bond's more than 60 years of manufacturing power transmission equipment has made it routine to specify our components for a great variety of design applications.

Check with your nearest Bond distributor, or contact Charles Bond Company for all your power transmission applications for:

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617-23 ARCH STREET • PHILADELPHIA 6, PENNSYLVANIA

Circle 510 on Page 19

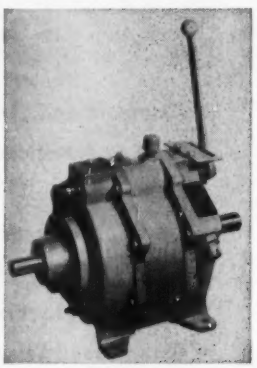
storage capacity. Air consumption is only 3 cu ft per minute (free air at 80 psi). **Martin Engineering Co.**, Neponset, Ill.

Circle 652 on Page 19

Reversing Transmission

transmits up to 8 hp at 2400 rpm maximum speed

Model 5131 reversing transmission combines two speeds forward, neutral, reverse, and speed reduction in a single compact unit. Only 10 in. wide, 10 in. high, and 12⅝ in. long, it transmits up to 8 hp at a maximum recommended input speed of 2400 rpm. Reduction ratio is 1.97:1; other ratios are 3.36:1 in forward speeds and 3.49:1 in reverse. Unit offers many possibilities in the design or redesign of agricultural, material handling, machine tool, and construction equipment wherever reversing is needed. **Industrial Div., Snow-Nabstedt Gear Corp.**, 251 Welton St., Hamden, Conn.



Circle 653 on Page 19

Pressure Control

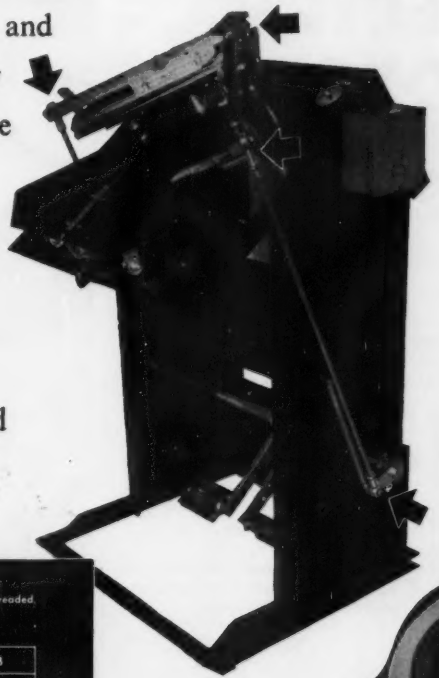
for pipeline use

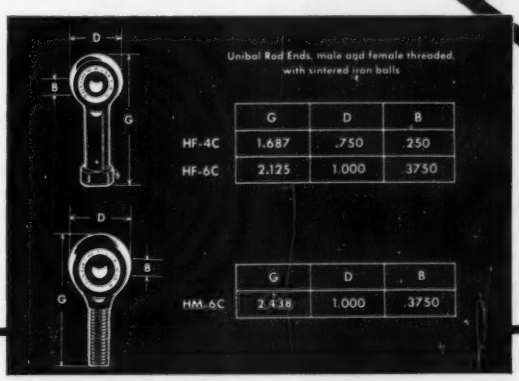
H98A dual-switch, explosionproof pressure control incorporates excellent stability features, maintains settings without drift, and can be mounted in any position without affecting calibration. Unit is designed especially for pipeline use. Two completely separate switches permit control of two independent circuits to simulate double-pole circuitry. Calibrated adjustment is protected by a tamperproof cap. Several models are available with calibrated ranges between 20 and 1700 psi, with proof pressure of 2500 psi and maximum

How to do it Better for less... with HEIM Unibal®

SPHERICAL BEARING ROD ENDS

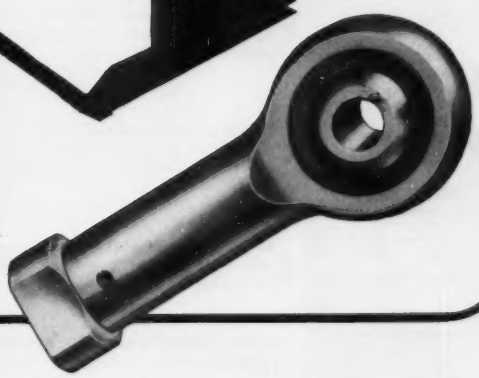
This is the Collar Shaping and Pressing Machine made by the Reece Folding Machine Company, which is a low-priced, manually operated device used in the shirt trade for shaping and pressing collars after they are sewed together, but before being attached to the shirt.





	G	D	B
HF-4C	1.687	.750	.250
HF-6C	2.125	1.000	.3750

	G	D	B
HM-6C	2.438	1.000	.3750



Unibal Rod Ends are used in five places, and were chosen for some carefully-thought-out reasons.

- *Unibal ball joints lower the machining and assembly cost.* A male Unibal is used at the fulcrum of the triangular pressing lever at top center. This allows the pressing plates to be easily lined up with the mating surface without expensive machining to close tolerances.
- *Long wearing qualities reduce replacement costs.* Reece says, "We have been using Unibal rod ends in our machines since 1947, and as far as we know, none have had to be replaced because of wear.
- *Solve design problems economically.* The use of Unibal "gets us out of some tough design problems quite economically, simplifies co-operating parts and makes final assembly easier."
- *Maintain easy, smooth action.* Heim Unibal rod ends are used to transmit motion from the lower shaft to the pressing plates between levers moving in arcs in different planes. They maintain the easy action necessary to manual operation.
- *Correct misalignment in all directions.*

The high quality and special advantages of Unibal Spherical Bearings and Rod Ends can save you time and money in the assembly of your machines. Ask our engineering department how. Send for the Heim complete catalog.

THE HEIM COMPANY Fairfield, Connecticut

ALL HEIM BEARINGS ARE AVAILABLE THROUGH THE LEADING BEARING DISTRIBUTORS IN THE U. S. AND CANADA

FELT
BY FELTERS

PROVIDES DEPENDABLE,
LOW-COST PARTS FOR

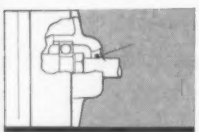
ELECTRIC MOTORS

Seals . . . wicks . . . lubricators . . . washers . . . gaskets — are all vital electric motor parts that benefit from Felt by Felters.

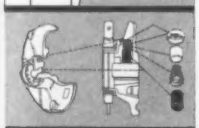
A special Felters' "Engineered Fabrication" processes felt to specific thickness, density, hardness, and resiliency; and provides special characteristics such as absorption, stiffness, water repellency and flameproofing.

And, new felt and plastic laminates, called PlastiFelts, use synthetics such as Nylon, Teflon, Hycar and rubber to provide an even wider range of application, plus greatly improved performance.

These are some of the many electric motor applications where Felt by Felters offers both a low-cost and high performance material for non-metallic parts.

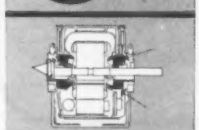


Felt seal inserted around shaft opening retains grease and keeps out foreign matter.

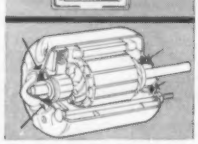


This self-oiler uses a felt wick, bearing against the shaft under spring pressure, for constant lubrication.

This is a thrust washer designed for double duty as a lubricator by the use of a felt ring and lubricating notches.



Lifetime bearing lubrication is possible by selection of correct SAE grade, and designing into sealed bearing.



Felters' "Engineered Fabrication" makes it possible to specify felt shapes for a complete motor and shaft lubricating system, combining reservoirs, and wicking, and directing oil flow to all required areas.

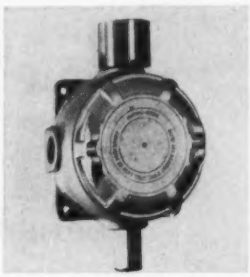
To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

Ask for **FELT** *from . . .*

The **FELTERS** Co.

271 SOUTH STREET
BOSTON 11, MASSACHUSETTS

Pioneer Producers of Felt and Synthetic Non-Woven Fabrics MD-6



pressure of 3500 psi. Control has a cast-iron base and aluminum cover suitable for Class I, Group C and D; Class II, Group E, F, and G; Class III. **United Electric Control Co.**, 79 School St., Watertown, Mass.

Circle 654 on Page 19

Epoxy Tubing and Plate

withstand corrosion in electrical apparatus

Available as tubing and plate, two new epoxy-and-fabric laminated materials have been developed for use in electrical apparatus where corrosive atmospheres are possible. Materials withstand immersion in a 15 per cent solution of sulfuric acid for up to 8 months. Tubing is convolute-wound dacron cloth and epoxy resin, available in lengths to 36 in. and diameters from ½ to 48 in. Plate is a dacron-cloth and epoxy-resin laminate, with sheet size of 36 x 36 in. Thickness ranges from 1/16 to 2 in. **Micarta Div., Westinghouse Electric Corp.**, Hampton, S. C.

Circle 655 on Page 19

Pillow Block

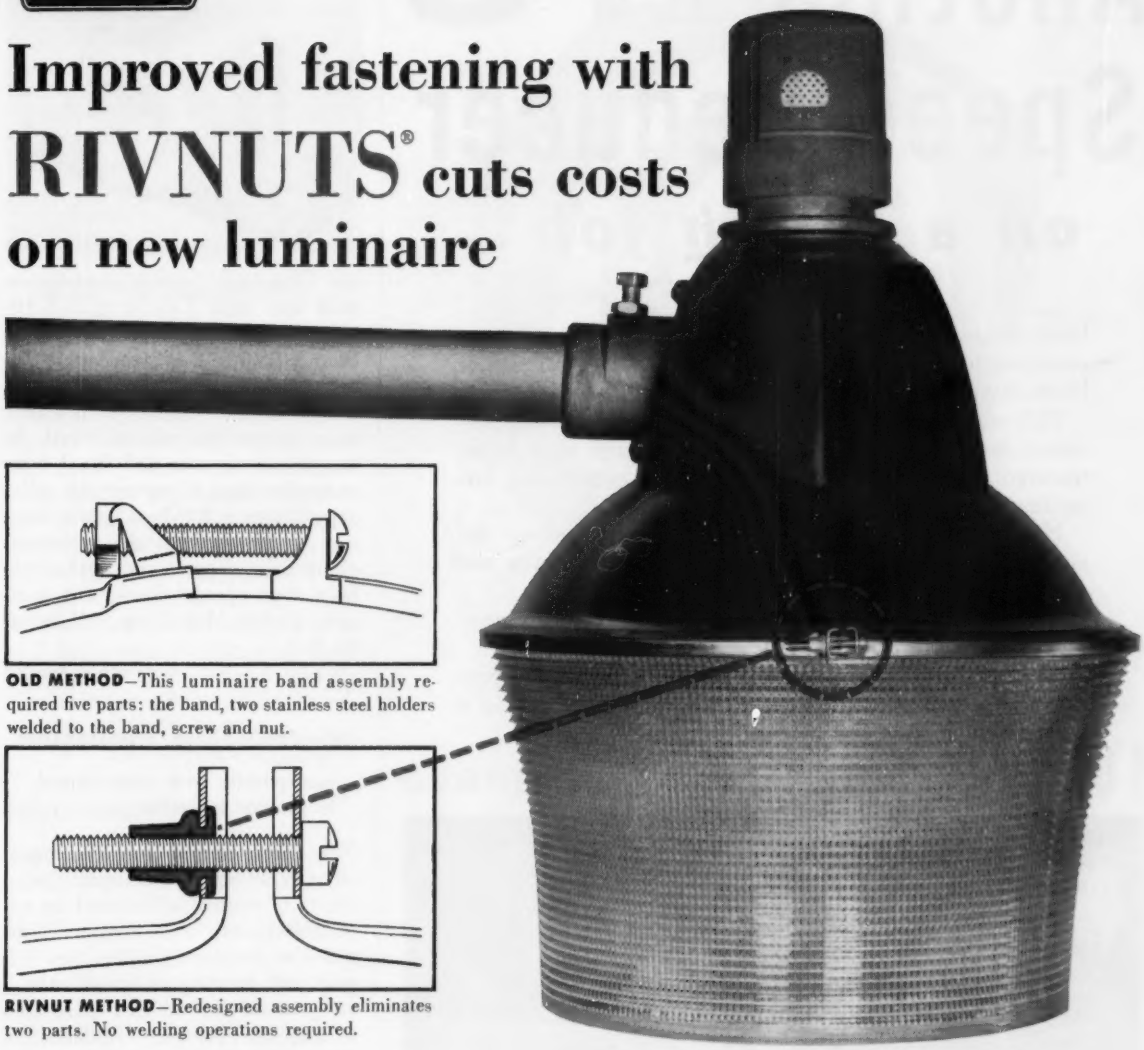
has replaceable bronze precision liners

Bronze-bushed pillow block is recommended for applications where shock loads, elevated temperatures, and corrosive conditions are anticipated. Only the cap of the block is removed to replace a worn bushing or liner, and shaft is lifted just enough to permit lower half of liner to be loosened and slipped out. New bronze liner can be inserted and seated by tapping lightly. No screws are required, and rotation of liner with shaft is prevented by a brass retainer spool recessed between cap and base of housing. Bronze-bushed line includes split journal bearings

Circle 512 on Page 19

B.F.Goodrich

Improved fastening with RIVNUTS® cuts costs on new luminaire



OLD METHOD—This luminaire band assembly required five parts: the band, two stainless steel holders welded to the band, screw and nut.

RIVNUT METHOD—Redesigned assembly eliminates two parts. No welding operations required.

The manufacturer of this outdoor lighting luminaire, Line Material Industries, McGraw-Edison Company, reports "considerable cost savings" since redesigning the luminaire holding band for RIVNUT fastening.

Five separate spot welds were eliminated, along with two parts. The RIVNUT is strong and secure. And unlike the old method, there's no loose nut to be dropped.

RIVNUTS are the only one-piece blind rivets with internal threads. They can be installed by one person, from one side of the work, in a few seconds with a heading tool. If you'd like recommendations on a specific fastening problem, please send a print of your part.

You can improve fastening in sheet metal, tubing, tanks with RIVNUTS

New data booklet describes principle, typical applications of RIVNUTS, lists size and tool data. For free copy write Dept. MD-5, *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*

B.F.Goodrich *Rivnuts*

Another H&S Speed Reducer

on a tough job . . .

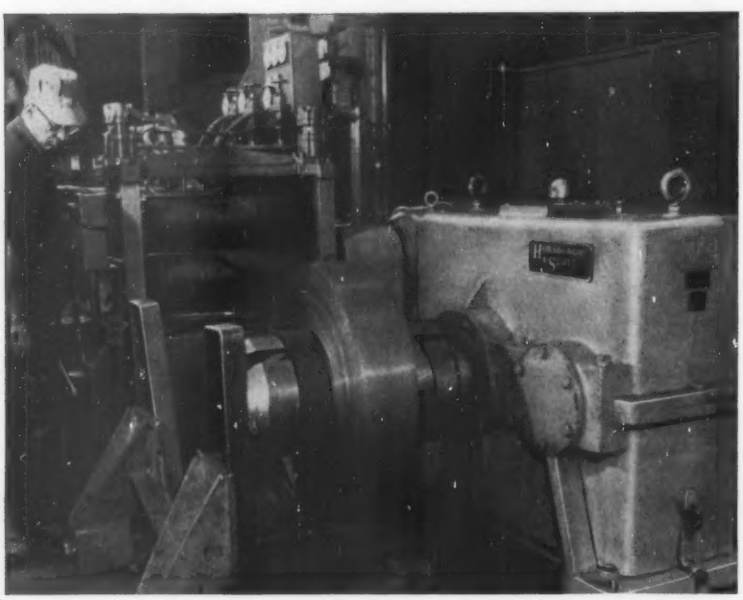
Built rugged for a critical rewind operation, this heavy overhung-load type H & S Herringbone Speed Reducer delivers day-in-day-out service under exacting load conditions.

This standard unit was selected for use on a Bliss precision rewind coiling machine—where strip steel must undergo tension controlled recoiling for subsequent annealing treatment.

Notice the sturdy shaft, with heavy-duty bearings designed to take this heavy overhung load. Observe the rugged housing, made to last.

This built-in toughness typifies H & S construction—on helical, herringbone, worm and combination units.

Send for detailed information on our facilities for producing a complete line of gears and speed reducers in a wide range of sizes and ratings.

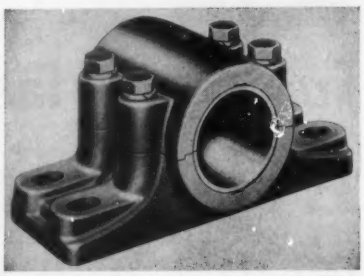


Heavily loaded pay-off reel being driven by H & S Speed Reducer in plant of The Acme Steel Company, Chicago.

The HORSBURGH & SCOTT CO.

5112 Hamilton Avenue • Cleveland 14, Ohio

Specializing in fast production of quality Speed Reducers and Gearing to meet custom requirements.



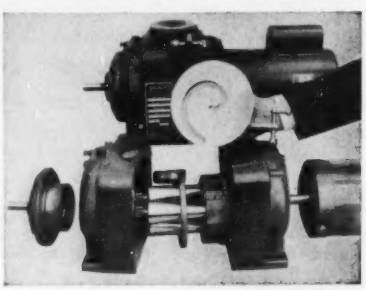
for standard power-transmission shaft sizes from 1 15/16 to 2 15/16-in., rigid pillow blocks for shafts from 3 7/16 to 8 in., and angle pillow blocks for all standard transmission shafts. Semisteel housings have tongue-and-groove joints in four-bolt base sizes and fitted bolts in smaller sizes to prevent cap shifting. Designed for heavy-duty service, bronze-lined blocks withstand elevated temperatures, relatively high shaft speeds, shock, and pressure. **Dodge Mfg. Corp.**, Mishawaka, Ind.

Circle 656 on Page 19

Adjustable-Speed Transmission

incorporates new cam control to provide linearity

New cam control provides equal changes in speed for equal increments of control adjustment in adjustable-speed transmission. Control also insures high accuracy setting and holding of speed over a range from any desired maximum to zero, plus reverse. Transmission speed is changeable with unit either running or stationary. Drive is a form of differential with one input corresponding to motor speed and other corresponding to rotative speed of planet rollers about their own centers. Differential action makes possible stalling of output shaft without damage to rotating parts. Transmission can be operated continuously at one speed setting



without fatigue of tractional members. It is available with or without motor. Micrometer, remote mechanical, electrical, or pneumatic controls are available. **Graham Transmissions Inc.**, Menomonee Falls, Wis.

Circle 657 on Page 19

Variable-Speed Belting

has link-type construction

Hypowa adjustable variable-speed belting is made in top widths from 7/8 to 4 in. for use on V-to-V variable-speed applications. It interchanges with molded endless variable-speed belts and wood-block belts. Exclusive strength member and increased plies per link provide maximum crosswise rigidity and high resistance to compression. Link-type construction permits quick assembly of any required length as well as extreme longitudinal flexibility. All belts are oil and heat resistant. **Brammer Corp.**, 486 Broadway, New York 13, N. Y.

Circle 658 on Page 19

Polycarbonate Resin

optically clear plastic has high mechanical strength

Merlon thermoplastic, a linear aromatic polyester of carbonic acid, has many applications in the electrical, automotive, lighting, general industrial, graphic arts, and engineering fields. Some applications include switchboard connectors, coil forms, relay bases, printed-circuit-card holders, safety helmets, drafting film, and heat-resistant diffusion lenses. Material has high mechanical strength, good electrical properties, excellent cold strength, high dimensional stability, low water absorption, and high heat stability. The optically clear plastic can be colored with dyes and pigments. It resists the effects of sun, rain, and extremes of atmospheric temperatures, and resists plastic deformation under long-term loading. The fire-retardant plastic is easily formed by standard methods and equipment, and is readily machined by tools and methods in common use for metals. **Mobay Chemical Co.**, 1815 Washington Rd., Pittsburgh 34, Pa.

Circle 659 on Page 19

BEARINGS & SEAL RINGS FOR 1200°F

When the heat is really "on" and ordinary graphite and even exotic metals fail, the new Stackpole 741 Graphite may well be your answer! Even surpassing Stackpole's famous 469 grade in oxidation resistance, Grade 741 paves the way for significant improvements in seals and bearings for jet engines and other high temperature applications.

Thanks to a new break-through in chemical processing, Stackpole Grade 741 operates reliably in the 1000° to 1200°F range and below. The material has a low coefficient of friction . . . exhibits very little wear even at maximum temperatures. And it retains graphite's inherently excellent self-lubricating properties.

741 High-Temperature Graphite is just one of numerous highly specialized carbon and graphite materials developed by Stackpole for difficult mechanical applications. To learn more about their economy and performance advantages, why not submit details of your applications to Stackpole for recommendation? STACKPOLE CARBON CO., St. Marys, Pa.

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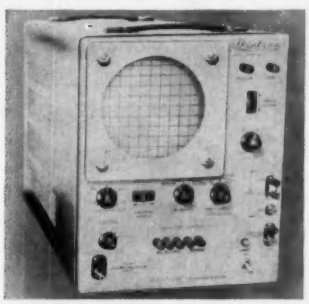
ENGINEERING DEPARTMENT

EQUIPMENT

Storage Oscilloscope

has 7-in. diam dark-trace tube

Model SK1001 storage oscilloscope is a general-purpose unit with excellent storage capabilities. Recurrent or transient signals are stored on 7-in. diam dark-trace tube which retains a viewable image indefinitely without blooming, even after all power has been removed. Display can be erased in less than 10 sec. Bright-room viewing is



possible because image is a dark line on an off-white background. Five pushbutton-selected sweep times are available. Built-in voltage calibrator is included. Unit measures 12 x 15 x 21 in., weighs 66 lb. **Skiatron Electronics & Television Corp.**, 180 Varick St., New York 14, N. Y.

Circle 660 on Page 19

Drawing Desk

has concealed drawing board

Drawing Chief desk is designed to serve as a standard desk and drawing table. Drawing board is concealed under desk top and elevated to posture-chair height by a raising mechanism when desk top is opened. When desk top is closed, drawing board is automatically lowered in a flat plane into a well which has sufficient clearance between drawing board and desk top for permanent mounting of draft-

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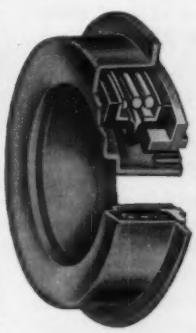
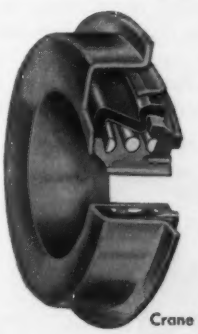


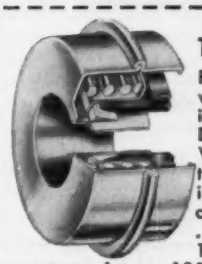
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 9-A

Packaged unit with wedge sealing ring made of DuPont Teflon. Will handle practically all known industrial chemicals and corrosives . . . pressures to 150 psi . . . temperatures from −120°F. to +500° F. Supplied in metallurgical specification best suited to the service.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb)
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

John Crane — CRANE PACKING COMPANY

ing machine. Clearance also eliminates necessity of removing tools or reference books from drawing board. Adequate storage facilities are provided for drawings, drawing paper, reference books, catalogs, files, and tools. Reference portion of the desk top slides out, allowing access to tool and supply compartment. Desk is available in different styles, desk-top sizes, electrical outlets, locks, and drawing-board pencil troughs. **Densmore Calculator Co.**, 2003 E. 14th St., P. O. Box 1557, Oakland 4, Calif.

Circle 661 on Page 19

Pressure Transducer

measures differential, absolute, or gage pressures

Type MM low-capacity, high-accuracy pressure transducer is of the bellows type and is suitable for most industrial, military, and laboratory applications. Electrical output can be translated for direct input to data-reducing equipment. Unit accurately measures differential, absolute, or gage pressures. Strain gages, bonded to an element which is contained within a hermetically-sealed metal case, undergo resistance changes when bellows assembly applies a force to the element. Resistance change is directly proportional to pressure.

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has the answer...

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Circle 518 on Page 19

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...you build into your products

with low cost LISLE *Magnetic* PLUGS

Many leading manufacturers increase the life and reliability of their products by installing Lisle Magnetic Plugs instead of ordinary drain plugs in any system where moving parts operate in a fluid.

The Lisle Magnetic Plug pulls out ferrous metal particles circulating in the fluid.

Tests conducted by Lisle Magnetic Plug **users** have proved its effectiveness — some more than doubling the service-free life of their products.

FREE Samples for Testing in Your Product

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Clarinda, Iowa

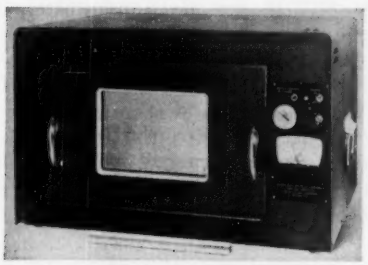
Circle 519 on Page 19

Output is 3 mv per v, with 350 ohms input impedance, standardized performance, complete interchangeability, high accuracy, and terminal linearity within ±0.1 per cent of full scale. Cell capacities are ±15, 30, and 60 psi. Unit operates on line pressure to 90 psi. **Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.**, 42 Fourth Ave., Waltham 54, Mass.

Circle 662 on Page 19

Temperature Chamber

portable unit has −100 to +500 F range



Precision temperature test chamber which accommodates rack-mounted electronic equipment permits prolonged temperature runs with stability to within ½ F over −100 to +500 F range. Model 7000A has an internal test volume of 19½ x 11 x 15 in. It attains a high degree of temperature stability through the use of a thermocouple and a precision meter-relay. Auxiliary timer is available as optional equipment. Liquid carbon dioxide is used for cooling. **Delta Design Inc.**, 7560 Girard Ave., La Jolla, Calif.

Circle 663 on Page 19

Drawing-Ink Remover

for use on all type of paper, cloth, vellum, plastic media

X-A ink remover eradicates all traces of India ink, regular ink, pencil and ball-point drawings, stamp-pad ink, and carbon. It is formulated for use on all types of tracing papers, vellums, cloths, and plastic media. It will not warp tracing paper or damage plastic foil, dries quickly so that drawing or copy printed over erased areas can be done almost immediately. **Alvin & Co. Inc.**, 611 Palisado Ave., Windsor, Conn.

Circle 664 on Page 19

Much stronger, they last longer when they're of reinforced *TFE

RULON®

Because Dixon's self-lubricating RULON has all the advantages of Teflon (low friction, chemical inertness, zero moisture absorption, extreme temperature range) PLUS a tremendous increase in mechanical strength and wear resistance, this engineered material is a natural for sealing applications. It exhibits no stick-slip characteristics . . . greatly reduces starting torques. And unlike rubber or leather, it retains its original dimensions, maintains positive contact with shafts or cylinder walls, and has infinite shelf life . . . being completely unaffected by weather, light, or heat. This material is now available with improved sealing action and at costs competitive with leather and rubber due to Dixon's new post-forming technique!

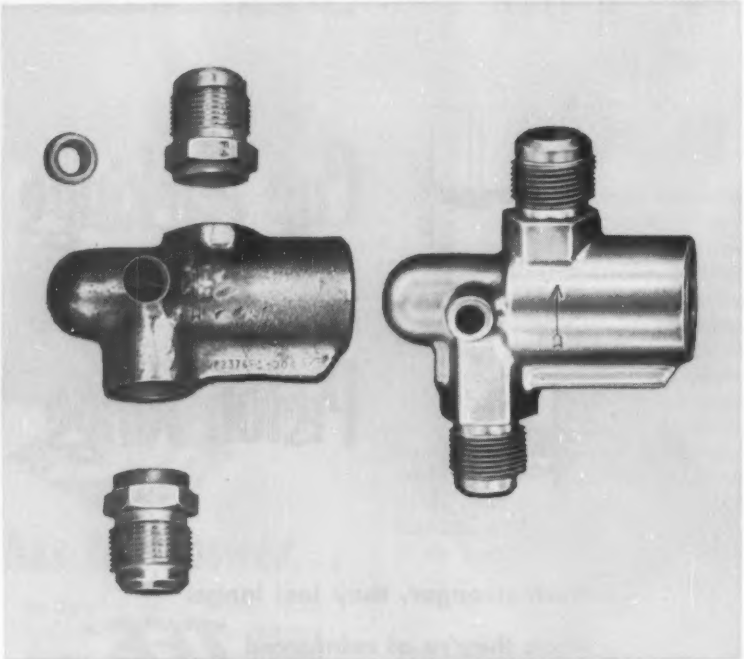
Want complete data? See our Catalog in Sweet's Product Design File, or ask for Brochure #9572.
DIXON CORPORATION, Bristol, Rhode Island

*DuPont Fluorocarbon Resin

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon

Circle 520 on Page 19

FOUR PARTS REDUCED TO ONE
—A BRIDGEPORT CORED FORGING STORY



The one-stroke Bridgeport cored forging on the right replaced the four-part casting assembly on the left.

The purpose of these valves is to control liquid under pressure. The four-part assembly shown on the left did not operate to fullest efficiency. Leakage frequently was present because of the porosity in the part's cast element.

The Engineering Staff at Bridgeport's Cored Forging Division designed the economical one-piece cored forging pictured on the right to abolish – once and for all – the leakage problem as well as many of the production steps.

The control valve is now all one unit. Assembly time has been eliminated and inspection time and part porosity are things of the past. Good, positive chucking for threading operations has reduced machining time to the necessary minimum. This simple, yet significant achievement, is an example of what Bridgeport's forging processes, both die and cored, can do for your component or part. Learn more about Bridgeport's forging facilities.

Write to Dept. 8902 for your copy of our detailed 16-page brochure, "Bridgeport Forgings."

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Recent Books

A New Table of Laplace Transformation Pairs. *By Ezra C. Levy; 107 pages, 8½ by 11 in., paperbound, stapled; available from Ezra C. Levy, c/o Space Technology Laboratories, Box 95001, Los Angeles 45, Calif.; $2.00 per copy.*

This Laplace transform table contains 1024 possible transformation pairs in nine sections. For practical reasons, no multiple - order pole greater than second order was chosen for the form of function $F(s)$. Also, for practical considerations, no characteristic polynomial denominator of $F(s)$ greater than the seventh order was included.

Complex Variables and Applications. *By Ruel V. Churchill, professor of mathematics, University of Michigan; 297 pages, 6¼ by 9¼ in., clothbound; published by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$6.75 per copy postpaid.*

Theory of functions of a complex variable is logically developed from elementary concepts to differential and integral calculus of analytic functions, residues, conformal transformations, and connections between analytic and harmonic functions. Then, the theory is linked to applications in engineering, applied mathematics, and physics.

This second edition contains new material on analytic continuation, behavior of functions near essential singular points, maximum moduli of functions, and linear fractional transformations. A new chapter on integral formulas of the Poisson type is also included.

Manufacturers' Publications

Zener Diode Handbook. *100 pages, 6 by 9 in., paperbound; published by and available from International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.; $2.00 per copy.*

A short introduction to semiconductor theory and reverse break-

down is presented. Then, design considerations, thermal and operating characteristics, and applications are examined. Applications include ac and dc circuitry, audio and rf equipment, computers and instrumentation, and circuit protection.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151895. Tensile Properties of Aircraft-Structural Metals at Various Rates of Loading after Rapid Heating. By J. Robert Kattus, Southern Research Institute; 187 pages, 8¼ by 10¾ in., paperbound; $3.00 per copy.
Results of five years of investigation of the short-time tensile properties of structural metals are analyzed. Specimens used in the test were heated to various high temperatures (up to 2400 F) within 10 seconds, held at this temperature from 10 sec to 30 min, and then loaded to failure at strain rates from 0.00005 to 1.0 in. per in. per sec.

PB 151933. Notes on Dynamics of Linear Elastic Structures. By G. J. O'Hara, U. S. Naval Research Laboratory; 19 pages, 7¾ by 10¼ in., paperbound, stapled; $0.50 per copy.
The normal-mode theory of calculating the dynamic response of linear elastic structures is explained and implications of the theory are discussed. A section on the seldom-published Duhamel integrals for simple linear oscillators is included, and an exact method of stress-checking a structure is presented.

PB 161145. Qualitative Aspects of Fatigue of Materials. By H. N. Cummings, Curtiss-Wright Corp.; 263 pages, 8¼ by 10¾ in., paperbound; $4.00 per copy.
Metal fatigue is measured in terms of cycles of loading and unloading. Variables affecting fatigue life and strength of structural metals are discussed qualitatively, and theories on the mechanism of fatigue are reviewed.

PB 161271, PB 161272, PB 161273. High Energy Rate Metal Forming. Each volume is 8½ by 11 in., paperbound, side-stapled; $5.75 per set.
This study evaluates the application of high rates of energy expulsion from high explosives to shape structural parts from sheet metal.
Report No. 1 defines the theoretical differences between dynamically and statically applied loads, and surveys the work of 27 companies in the metals field.
Report No. 2 describes the facilities that were constructed, design and manufacture of required tooling, preparation of materials, and instrumentation required for forming tests.
Report No. 3 describes the initial series of tests performed. An evaluation of the results of high-explosives application is presented.

NASA Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TR R-21. On Solutions for the Transient Response of Beams. By Robert W. Leonard, Langley Research Center; 33 pages, 8 by 10½ in., paperbound, stapled; $0.40 per copy.
Williams-type modal solutions of the elementary and Timoshenko type are presented for the response of several uniform beams to a general applied load. Example computations are shown for a free-free beam subject to various concentrated loads at its center. Results obtained by two numerical procedures are presented and discussed.

TR R-28. Practical Solution of Plastic Deformation Problems in Elastic-Plastic Range. By A. Mendelson and S. S. Manson; 24 pages, 8 by 10¼ in., paperbound, stapled; $0.40 per copy.
Presented is a practical method of using successive approximations to solve plastic deformation problems in the elastic-plastic range. The method is illustrated by four examples: A flat plate with temperature distribution across its width, a thin shell with axial temperature distribution, a solid cylinder with radial temperature distribution, and a rotating disc with radial temperature distribution.

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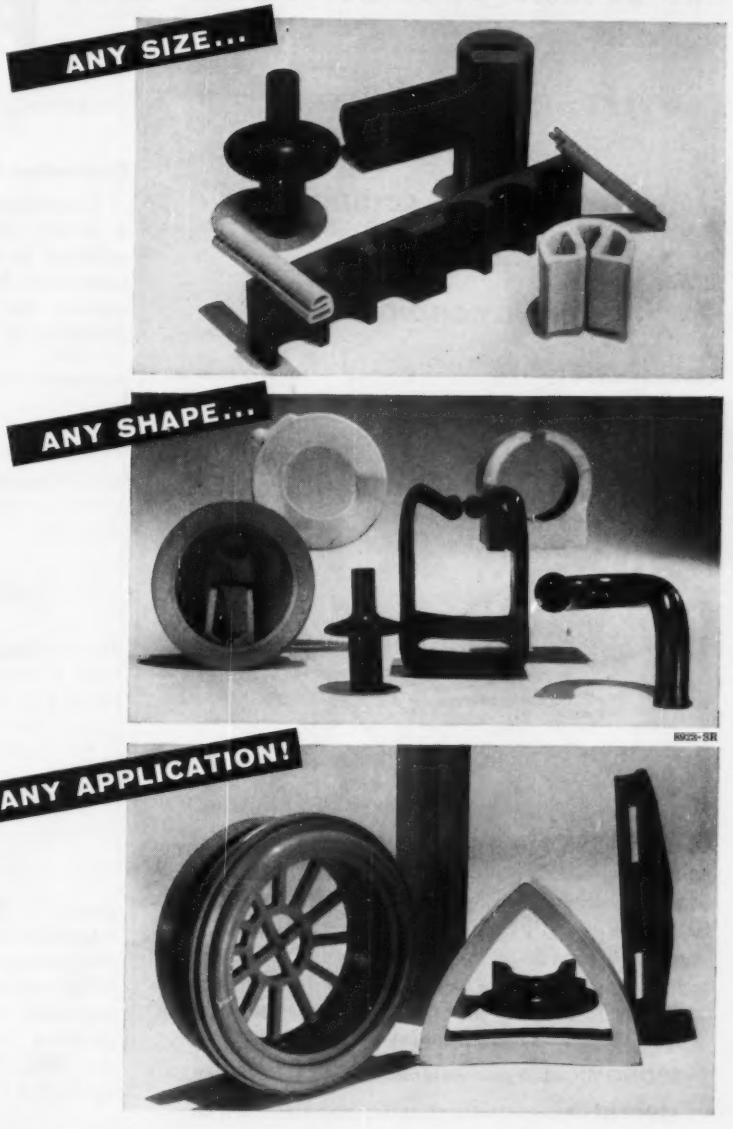

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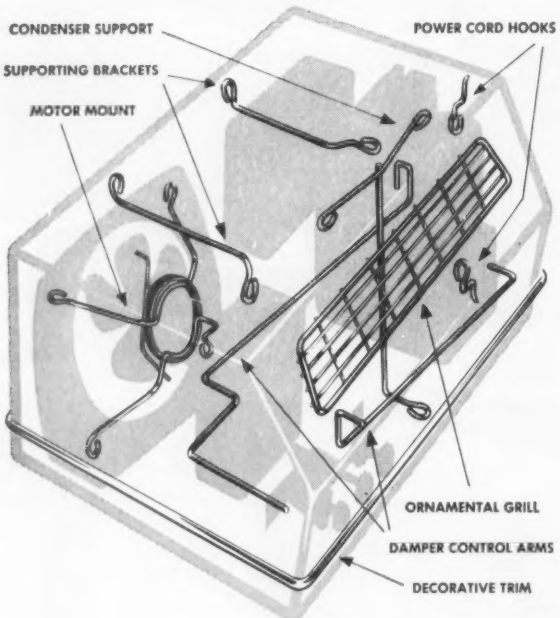
Circle 522 on Page 19

working wonders
with WIRE

Versatile wire components fill 7 functions in air conditioner



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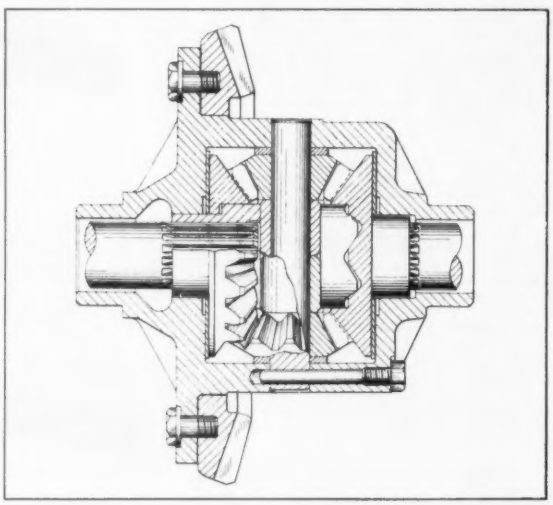
NOTEWORTHY

Patents

Controlled-Slip Differential Drive

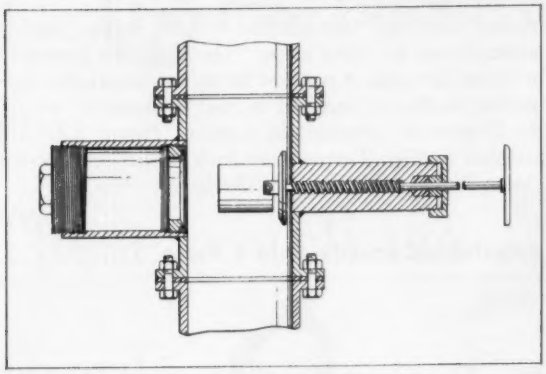
Transmission of torque to a nonrotating wheel on a motor vehicle when the opposite wheel slips is achieved in a differential unit by cam-activated axle gears with friction-clutch surfaces. Slip splines, which connect the axles to bevel gears of the differential, permit each gear to move axially under load to engage the friction-clutch surfaces. When the wheels rotate at different speeds, the cam contours increase the pressure of clutch engagement for the slower wheel. When one wheel has a tendency to spin, self-energizing clutch action assures delivery of torque to the nonspinning wheel according to the load unbalance. *Patent 2,932,218 assigned to Eaton Mfg. Co., Cleveland, by Robert C. Russell.*



Pawl and ratchet mechanism uses a single pawl element to rotate and lock a ratchet wheel in either direction of operation. The wheel has radial teeth. The pawl, which is a piece of spring steel of shallow U shape, pivots upon an actuator plate. One leg of the U is in driving engagement with a tooth on the wheel. The other leg, which is several teeth away from the driving leg, engages another tooth to lock the wheel. Mechanism operation is controlled by an electric relay. *Patent 2,926,547 assigned to Bendix Aviation Corp., Baltimore, by Frank O. Watson.*

Corrosion-Testing Device

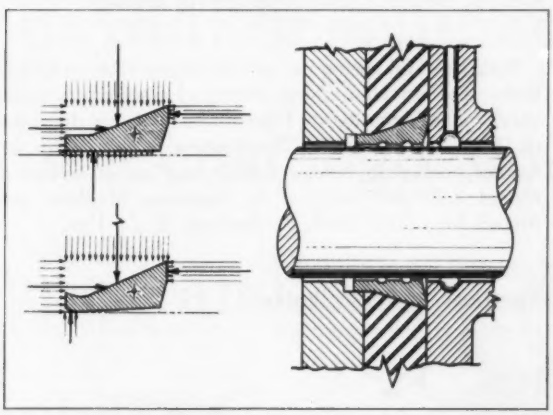
Pipe assembly of special design provides for the subjection of corrosion test specimens to actual service con-



ditions without interruption of fluid system operation. Specimen is carried into and out of the flow stream on an extension of a screw-type valve stem. Specimens are attached to the valve stem for testing in a chamber diametrically opposite the screw-nut unit. A valve element, which is also carried by the valve stem, engages a conical seat to seal the line against leakage during attachment and detachment of the specimens. *Patent 2,928,726 assigned to the Standard Oil Co., Cleveland, by Richard W. Oberly.*

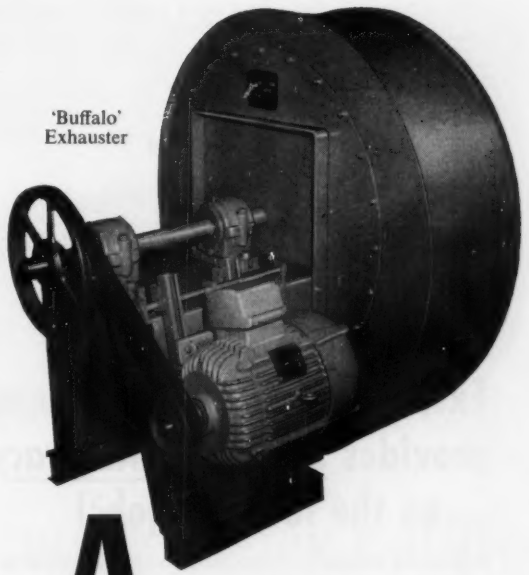
High-Pressure Piston-Rod Seal

Leaktight sealing of a piston rod for high-pressure operation, as in a liquid spring, is achieved by a four-ring seal assembly. The main seal element is a metal ring of wedge-shaped section and distorts under pressure. The metal seal ring is confined radially by a



rubber disc. When the rubber disc is compressed axially by metal plates on either face, the metal seal ring is squeezed against the rod. A low-pressure liquid region in the external metal plate surrounds the rod and aids sealing action. *Patent 2,930,608 assigned to Cleveland Pneumatic Industries Inc., Cleveland, by Walter H. Hogan and Anthony V. Camino.*

Small strain gage provides an expendable supporting medium for attachment of the electrical resistance element. The electrical element is a continuous filament of equal and parallel portions making 180 deg turns at the ends. The ends protrude beyond the sup-



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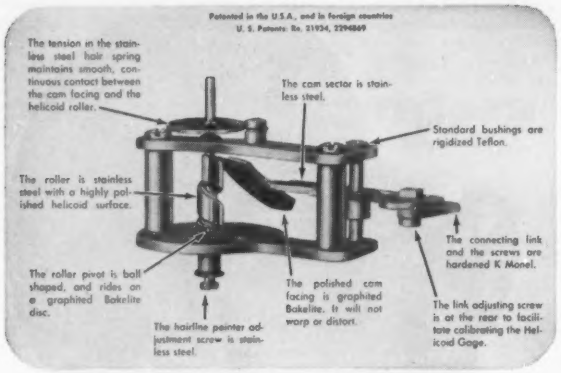
Circle 524 on Page 19


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
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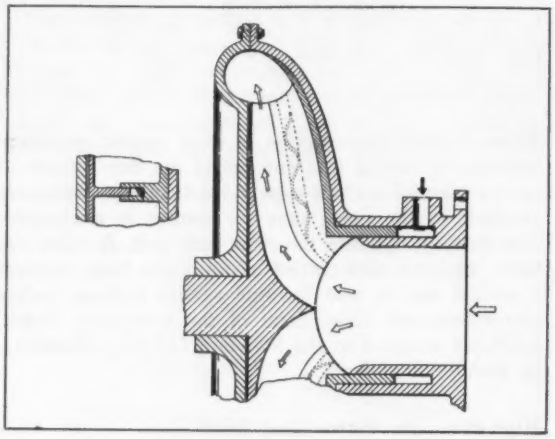
porting medium. Attachment of the strain gage is accomplished in three steps: The ends are cemented to fasten the gage in position for measurement, the supporting medium is removed by heat or chemical solvent, the filament is cemented in position. *Patent* 2,927,878 *assigned to High Temperature Instruments Engineering Corp., Philadelphia, by Paul Beckman.*

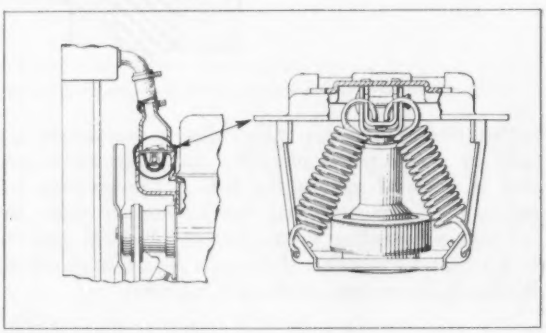
Adjustable-Capacity Rotary Pump



Fluid capacity in an impeller-type pump is varied with an adjustable shroud between the impeller and the pump housing. Axial displacement of the shroud toward or away from the impeller reduces or increases the pumping volume. *Patent* 2,927,536 *assigned to General Electric Co. by John Merrill Rhoades.*

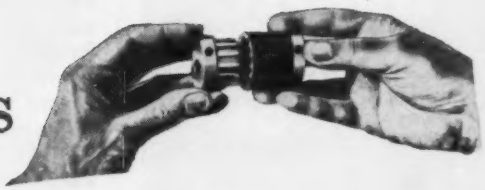
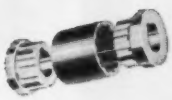
Spiral-wound spring motor uses plastic film on spring surfaces to provide uniform friction characteristics under varying load conditions. Film thickness is on the order of 0.0002 to 0.0007 in. The coating is applied to the spring steel strip before coiling and stress relieving. *Patent* 2,932,503 *assigned to American Machine and Metals Inc., New York, by Ambrose E. Le Van.*

Shaftless Butterfly Valve



Basic elements of butterfly-type valve are a hat-shaped valve seat with semicircular pivot housings and a companion valve element grooved near the middle to seat in the pivot housings. The opening in the valve

US RUBBER **PowerGrip** FLEXIBLE COUPLINGS

These couplings  are so simple in design  that their cost is LOW compared with other couplings. Insist on having U.S. PowerGrip Flexible Couplings tried on your machinery and then watch your costs go down. Installation is quick and easy. No maintenance, no lubrication. Call now!

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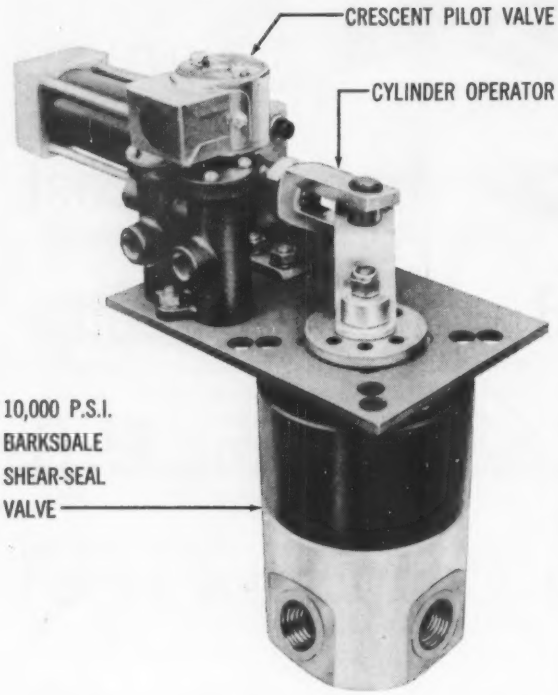

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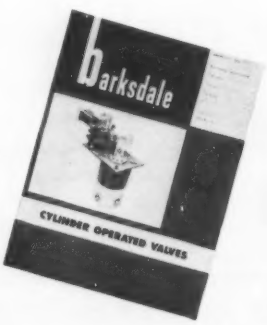

CONTROL VALVE DIVISION
Barksdale valves
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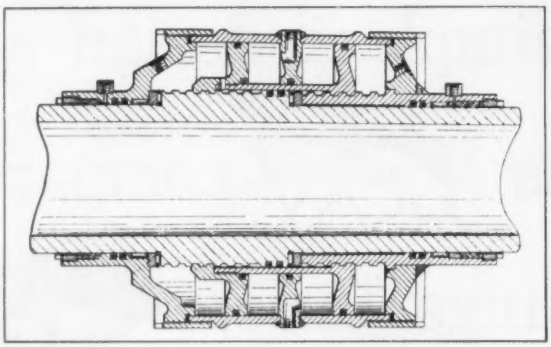
seat is oval shaped with the narrow dimension between the pivots. The valve element is shaped to hook underneath the valve seat along one direction of a major diameter and to overlap the valve seat in the opposite direction from the pivot. In operation, the valve element is held against the valve seat by springs until forced open by a thermostatic unit of conventional type. *Patent* 2,929,396 *assigned to General Motors Corp., Detroit, by Adolf Schwarz.*

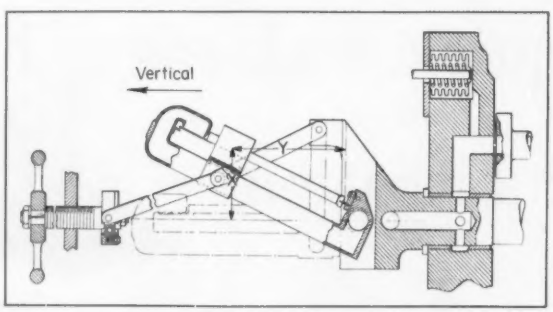
Twin-Piston Rotary Actuator



Tandem pistons in a divided cylinder provide nearly double the effective pressure area, and force output, of a comparable single piston arrangement. Longitudinal displacements of the pistons are transformed into rotary motion by helical splines. *Patent* 2,932,206 *assigned to General Motors Corp., Detroit, by James N. Tootle.*

Speed-Compensating Governor

Uniform governing sensitivity over a wide range of speeds is provided by a rotating spindle which carries fluid axially to a pressurizing and bleed-valve assembly. This valve unit is controlled by a centrifugal flyweight on an adjacent spindle. Slight movements of the fly-



weight alter dimensions *X* and *Y* shown in the illustration and cause the bleed valve to open or close. Corresponding variation in the amount of fluid flowing decreases or increases the pressure in the spindle. These pressure variations are transmitted to a transducer device for regulating speed in a conventional manner. *Patent* 2,929,389 *assigned to General Electric Co. by Stephen Jacobs.*

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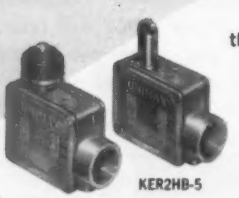

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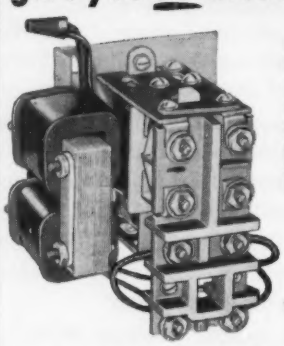

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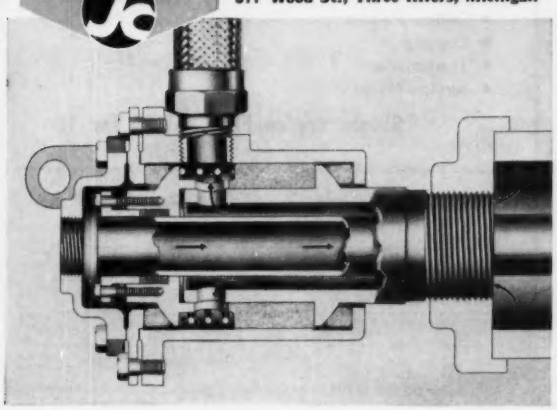

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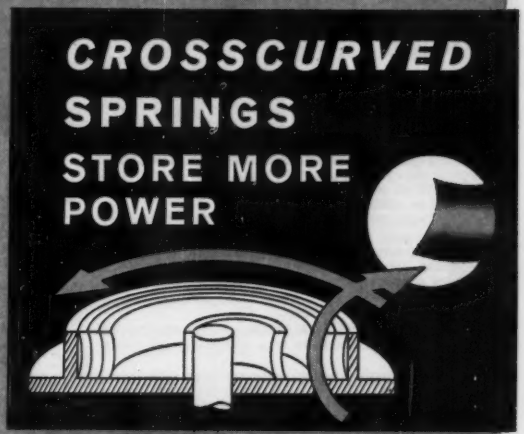

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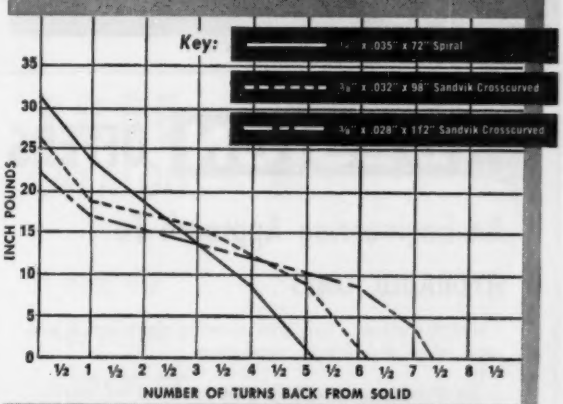

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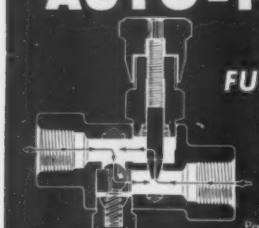

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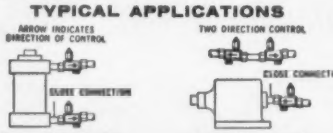

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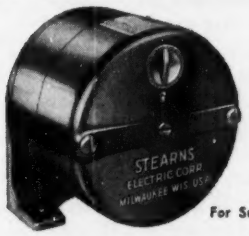

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- ✓ Exclusive Stearns "Visi-wear-indicator". ✓ Fully assembled.

For Superior Performance . . . Specify Stearns!
Request Bulletins 226-H and 3502-F

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push-pull CONTROLS

Compression & Tension Type

Aircraft cable is strung with spherical steel shells in a rigid or flexible housing sealed with "O" rings. 3" standard bend radius. ¾" minimum bend radius.

Three Types:

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Positive remote controls for actuating mechanical, hydraulic or other devices. Eliminate bell cranks, pulleys and dual cables. U. S. Patent No. 2441719. All world rights reserved. Send for ENGINEERING MANUAL No. 1551 giving complete specifications covering materials, finishes, capacities. Please address Dept. MD-PP-60.

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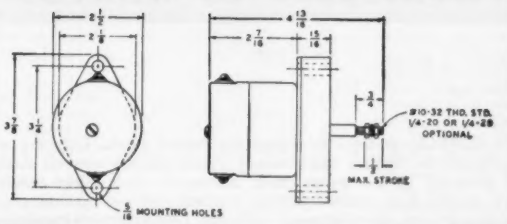
D. C. SOLENOIDS



Synchro-Start SL SERIES SOLENOIDS

are for operating engine throttles, fuel pump racks, chokes, etc. and are available with several variations. Other models in 1" and 1½" strokes.

VOLTAGES (D. C. Only)
6V. 12V. 24V. 32V.

CURRENT DRAW (Pulling)
55A. 35A. 15A. 12A.

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1.6A. .8A. .4A. .3A.

DUTY
Continuous

CYCLES
Not to exceed 6 per minute

PULL
Approximately 10 lbs. over ½" stroke

WEIGHT
2¼ pounds

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE · SKOKIE, ILL.

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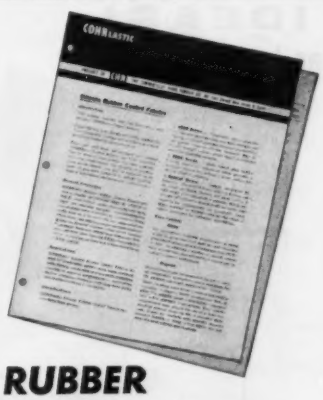
FREE CATALOG



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OPERATION ASSURED... REGARDLESS OF PRESSURE DROP OR FLOW CONDITIONS

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SENIOR MECHANICAL ENGINEERS for commercial product design involving mechanism and kinematics. Four to ten years of experience required to fill positions created by an expanding line of products. Plant visit and moving expenses are company paid. For further information send résumé to: E. Faro, Technical Placement Director, Bausch & Lomb, 635 St. Paul Street, Rochester 2, N. Y.

BAUSCH & LOMB

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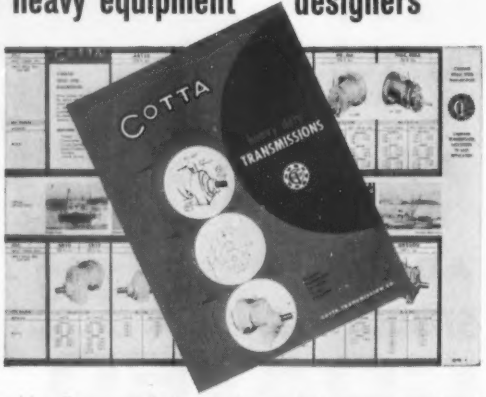
IDEAS!

for heavy equipment designers



Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

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- Wide variety of "engineered-to-order" transmissions
- Specifications (capacities, speeds, gear ratios) for heavy-duty applications
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Send coupon for your free copy . . . or see our Catalog No. 3a/Co in *Sweet's Product Design File* today!

Cotta Transmission Co., 2340 - 11th Street, Rockford, Illinois
Please send my copy of "Cotta Heavy-Duty Transmissions" to
Name_____ Title_____
Company_____
Address_____
City_____ Zone_____ State_____

Circle 545 on Page 19

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BPA NBP

backtalk——

—The Boss

Robert L. Hartford, newly appointed publisher of MACHINE DESIGN, has the distinction of being one of the youngest old employees of The Penton Publishing Co. Bob began his career as an editor on *Steel* right after graduating from Ohio University in 1936. He moved to Pittsburgh as regional editor for all Penton

magazines, then returned to Cleveland in 1945 to become manager of market research for MACHINE DESIGN. Four years later he was named business manager, a position which he continues to hold. As publisher, Bob has over-all responsibility for MACHINE DESIGN's operation.

—Brass into Gold

If you have a new use for a bronze or brass casting—either in hand or in mind—you can enter the First Annual Brass and Bronze Progress Awards contest sponsored by the Brass and Bronze Ingot Institute. Awards (first prize, $500) will be made in each of the two categories "Progress" and "Projection" for actual and suggested new uses of a brass or bronze casting, substitution of such a casting for another material in an existing product or part, or for improved design or efficiency of a casting now in use. Entry blanks and information can be obtained from BBII, 300 W. Washington St., Chicago 6, Ill.

—Anyone for Summer School?

Beginning in this issue, we are extending the Meetings and Shows listing to include "Short Courses and Symposia" (Page 46). We figure that, with summer practically here, you will be looking for a place to spend your vacation. And what could be nicer than a college campus in the off season.

We are not only reporting the seminars, but are taking an active part in at least one. Colin Carmichael will give a talk, "The Design Engineering Function in Industry," at the Design Engineering seminar to be held at Penn State in June.

—The Giftie To See Oursels

There are umpteen hundred thousand engineers in this country; 200,000 of them read MACHINE DESIGN; and our readership surveys show that about 75 per cent of these read the series, "The Engineer—Paragon or Paradox?" published last December and January. The first of the three articles contained a list of engineers' characteristics and boxes for rating oneself (Dec. 10, 1959, Page 25). If a reader wanted to "blow off steam," we invited him to send in a filled out rating for comparison with others. So far, 17 answers have come back—which seems to bear out the observation that engineers are not highly interested in communications.

In 150 psychological studies correlated by the articles' author, the "norm" engineer rated high in cautiousness, enthusiasm for work, conformity, perfectionism, professional ambition, and ability to work under pressure. Counts on which he ranked low are: Diplomacy, introspectiveness, tolerance for intangibles, persuasiveness, and communication skills.

Our respondents graded themselves higher on most counts than the norm and somewhat lower on cautiousness, conformity, and perfectionism. One didn't use any of the "very low" or "low" boxes, and he added another category: Ego—very high.

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another new Westinghouse AIR CIRCUITRY Component

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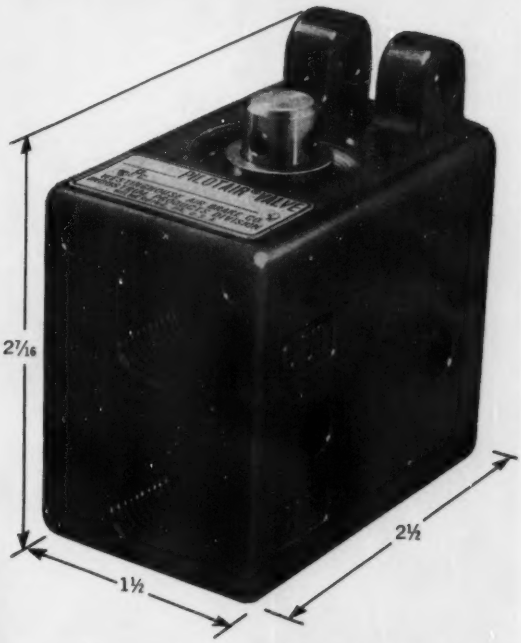

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They can open, close or vent an air circuit as quickly, efficiently and dependably as models twice their size.

For despite their compactness (actual dimensions are 1½" x 2½" x 2 1/16"—and they weigh less than 16 oz.), the short travel action of poppet valve construction produces fast response for full valve capacity.

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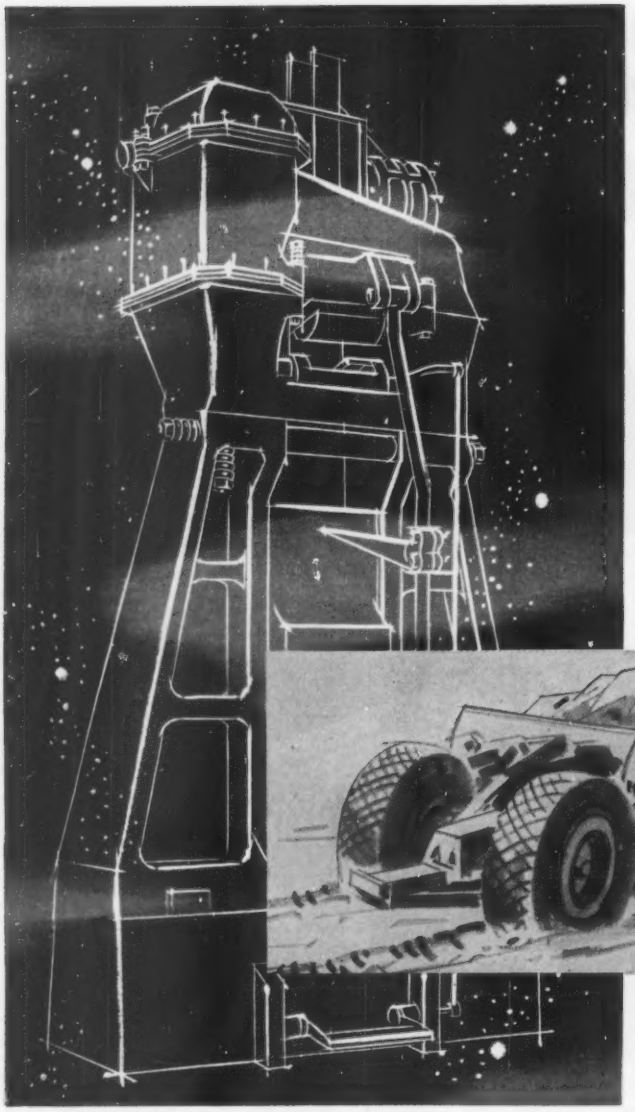


Modern board forging hammer

DEPENDABILITY of shifter fork improved by designing it to be FORGED

By designing the shifter fork of his transmission to be forged, a manufacturer of earthmovers eliminated costly equipment breakdowns in the field because of fork failure. Factor of safety was *in*creased even while weight and over-all costs were being *de*creased.

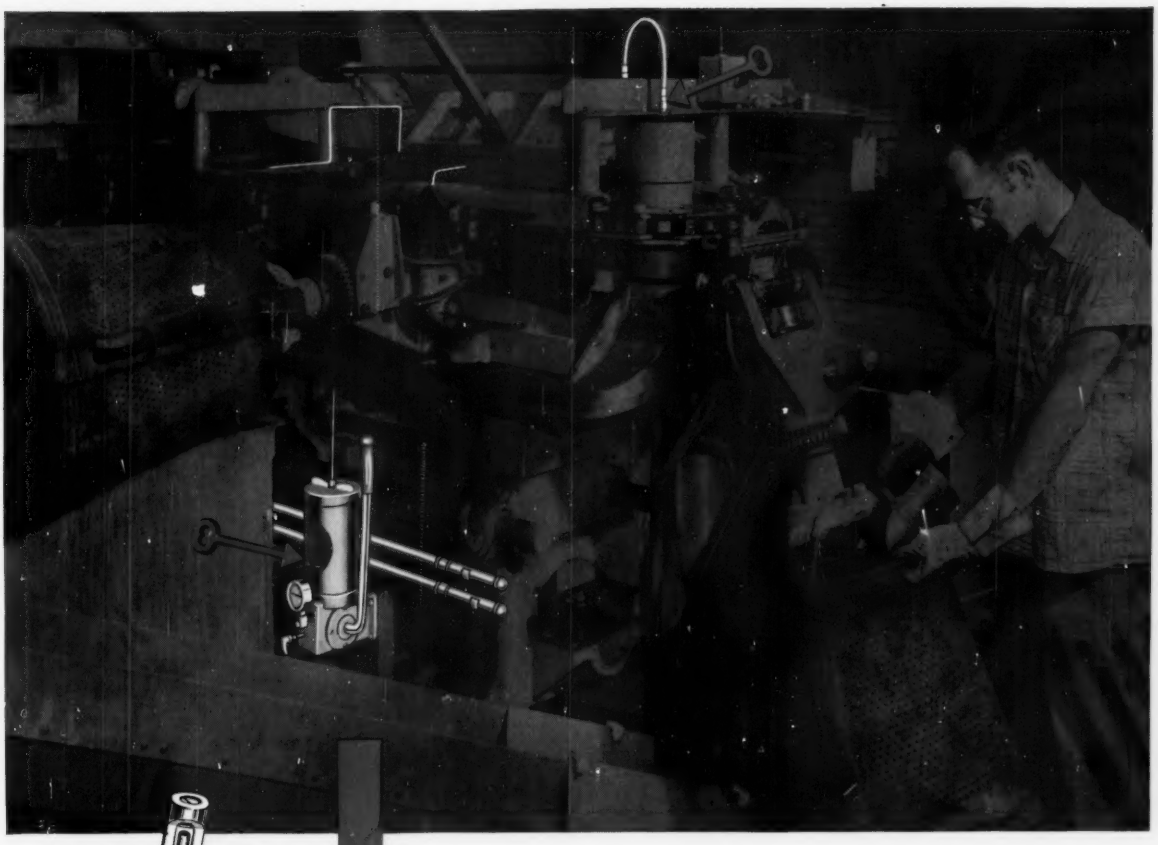
Parts scrapped because of voids uncovered after much high-cost machining are eliminated . . . forgings are *naturally* sound all the way through. Forgings start as *better* metal . . . are further *improved* by the compacting hammer-blows or high-pressure of the forging process.

Design your parts to be forged . . . increase strength/weight ratio, reduce as-assembled cost, improve performance. Literature to help you design, specify, and procure forged parts is available on request.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine



FARVAL—
Studies in
Centralized
Lubrication
No. 229

Farval cuts downtime on automatic plating machine

Quantity production is a prime purpose for automatic machines such as this Stevens plater. Bearing failure, long the enemy of automatic processes, is eliminated on this plating machine at a prominent Midwestern automotive parts plant through application of a Farval lubrication system. Downtime for repair of bearings is virtually eliminated.

This Farval system provides measured amounts of lubricant to each bearing at regular intervals. Large ports on Farval systems insure adequate lubrication without dangerous line pressure loss or grease separation.

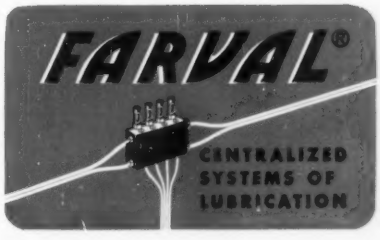
Learn how you can cut downtime with an application of a Farval system to your process or machinery. Ask for revised Bulletin 26-T. Write . . .

Farval Division • Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio

EATON

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



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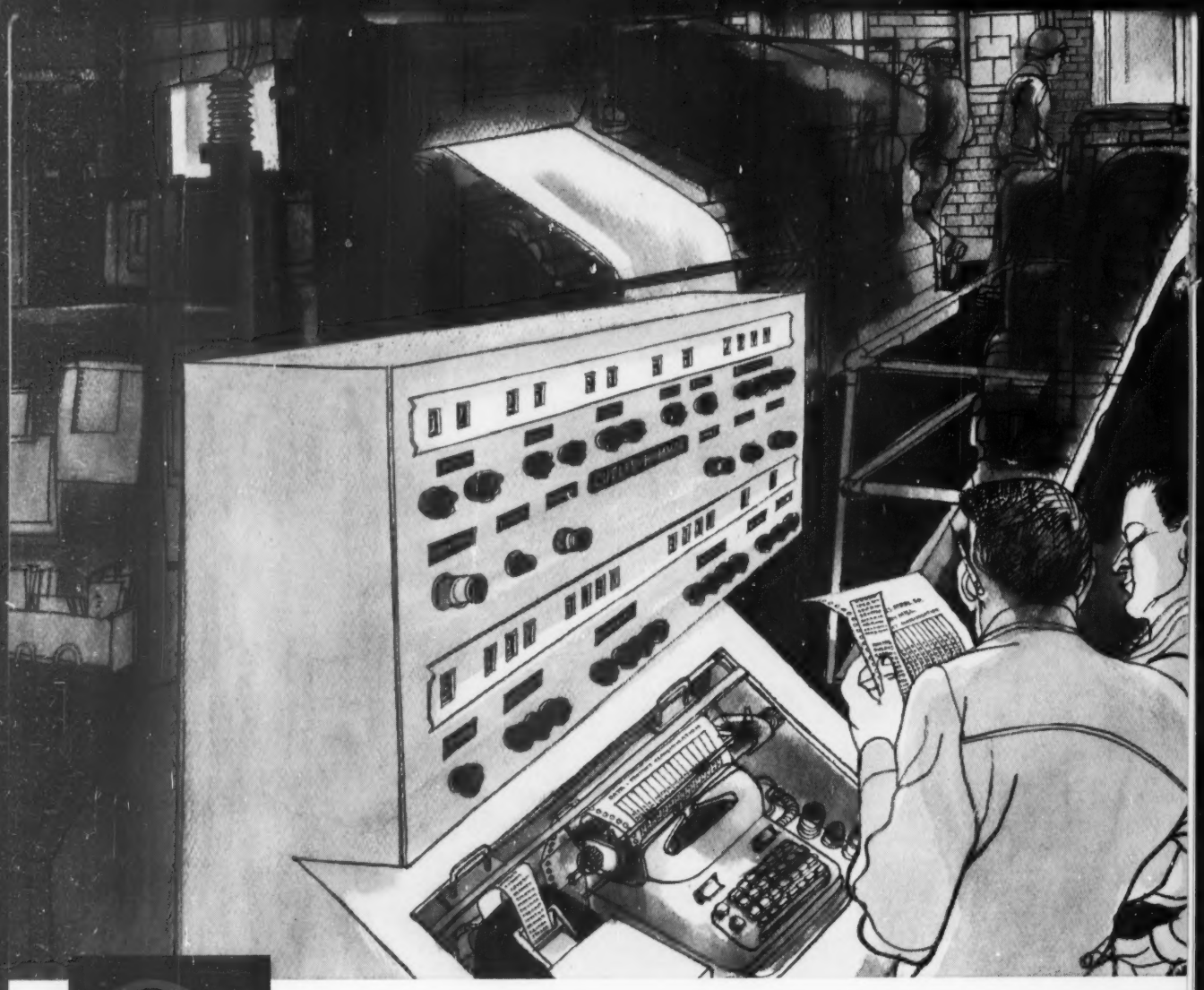

CONTROL

New machine with a memory licks a quality problem 3 miles long!

It's relatively simple to control quality of tinplate sheets by running them individually through sensing stations. But, how do you check and control quality in a *coil* of tinplate up to 16,000 feet long?

Working with a leading tinplate producer, Cutler-Hammer engineers devised an ingenious new type of computer that hooks right onto the sensing stations and automatically keeps track of every defect. When the tape is checked, production controls can be quickly adjusted to compensate for any deviation from standard.

This is an example of the new thinking, the new vitality at Cutler-Hammer. We're on the move . . . with new products, new ideas, new engineering talent. We've solved problems that other companies in our field wouldn't even tackle. One of our divisions, with extensive microwave and electronic experience, gives us even more creative muscle in all fields of industrial automation.

Even our trademark's new, to symbolize the new Cutler-Hammer. Phone one of our sales offices and see how we can fit on your team.

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C.A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation

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